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(52) UK CL (Edition K)
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(56) Documents cited
None

(58) Field of search
NO SEARCH POSSIBLE

(54) **Full-automated washing machine and full-automated washing and drying machine**

(57) In a full-automated washing machine and a full-automated washing and drying machine, the cloth amount is detected at the time that the operation is started by charging the washing into a drum (27) serving as a container in advance of teeming water, the cloth amount is decided as to whether to be permissible for drying or not and a decision result is displayed in advance of teeming water, and the user is urged to select any one of washing, rinsing, dehydration and drying processes by means of operation/input means (73) in advance of teeming water, thereby permitting operations under various conditions (the kind of cloths, the manner of laying cloths and ambient circumstances). The operation is decided as to whether to extend to drying or not in terms of at least three steps of fuzziness to ensure selection of any one of washing and drying processes even under a variety of conditions of cloths. Similarly, if the decision determines that the cloth amount should be decreased, if possible, for the purpose of sufficient drying, either the operation (course) which ends in dehydration following washing or the operation (course) which extends to drying can be carried out by selectively triggering automatic setting means; and if the cloth amount goes beyond a value permissible for drying to a great extent, execution of the drying process is inhibited. In detecting the cloth amount, the drum (27) serving as the container is once started and subsequently the power supply (88) for the motor (35) is turned off to cause the drum to continue rotating by inertia and then stop, so that a value corresponding to an overrunning amount of the drum may be determined; and in addition, the motor adapted to drive rotation of the drum is supplied, upon starting, with power which gradually varies from a low level to a high level and when a rotational position detector (1) carried on the rotary shaft (33) of the drum detects start of the drum, a value corresponding to a level of power supplied at that time (minimum level of power necessary for starting the motor) is determined. Then, a decision criterion for cloth amount is determined on the basis of the two values. Supply of power may be controlled by controlling the angle of electric conduction (conduction angle) of AC power supplied to the motor.

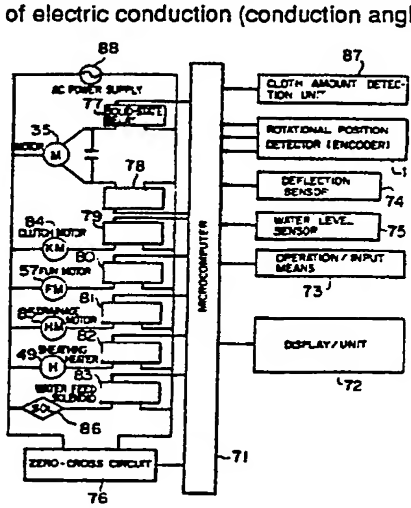


FIG. 1

GB 2 247 250 A

FIG. 1

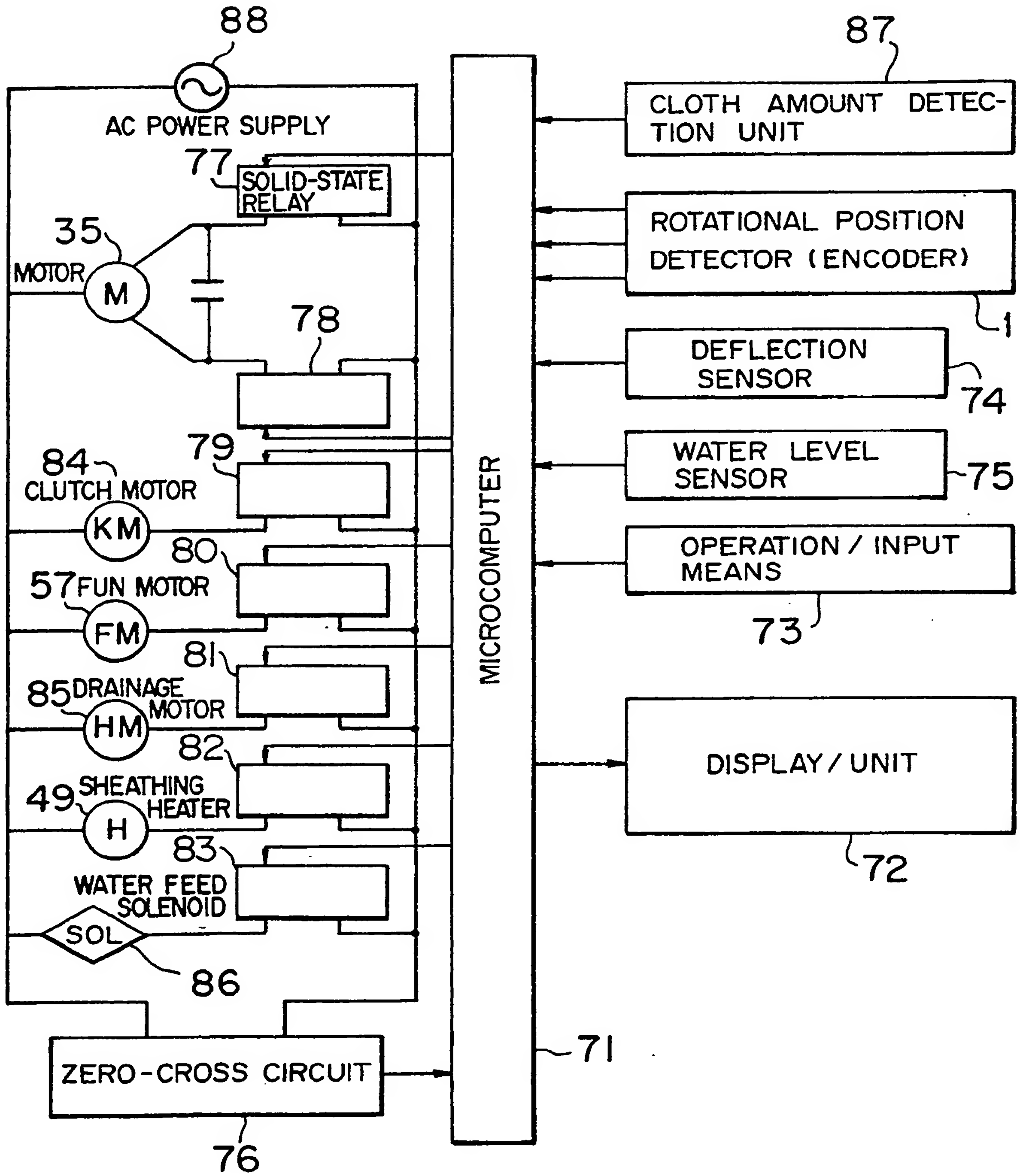

88
AC POWER SUPPLY
77
SOLID-STATE RELAY
35
MOTOR
M
78
79
84
CLUTCH MOTOR
KM
80
57
FUN MOTOR
FM
81
85
DRAINAGE MOTOR
HM
82
49
SHEATHING HEATER
H
83
WATER FEED SOLENOID
SOL
86
ZERO-CROSS CIRCUIT
76
MICROCOMPUTER
71
87
CLOTH AMOUNT DETECTION UNIT
ROTATIONAL POSITION DETECTOR (ENCODER)
1
DEFLECTION SENSOR
74
WATER LEVEL SENSOR
75
OPERATION / INPUT MEANS
73
DISPLAY / UNIT
72

FIG. 2

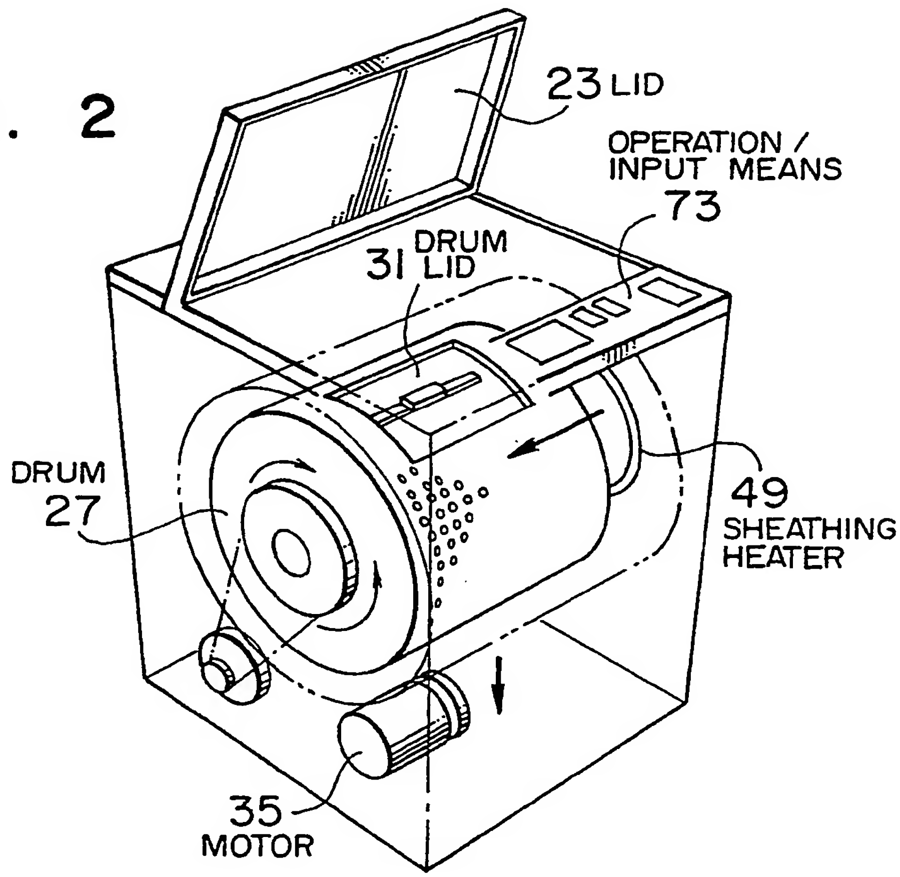

23 LID
OPERATION / INPUT MEANS
73
DRUM LID
31
DRUM
27
49
SHEATHING HEATER
35
MOTOR

FIG. 3

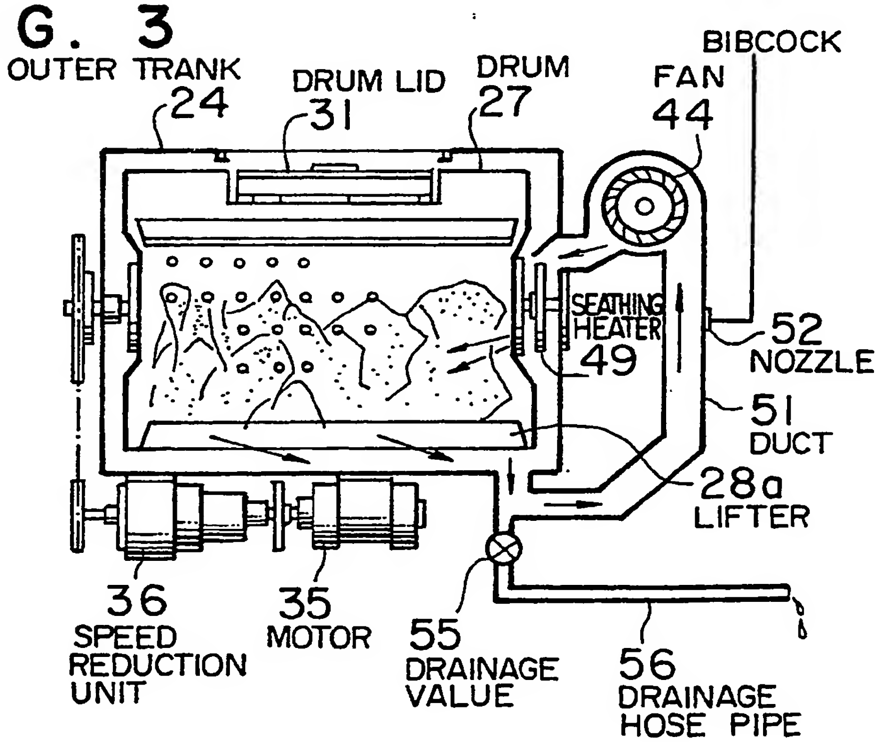
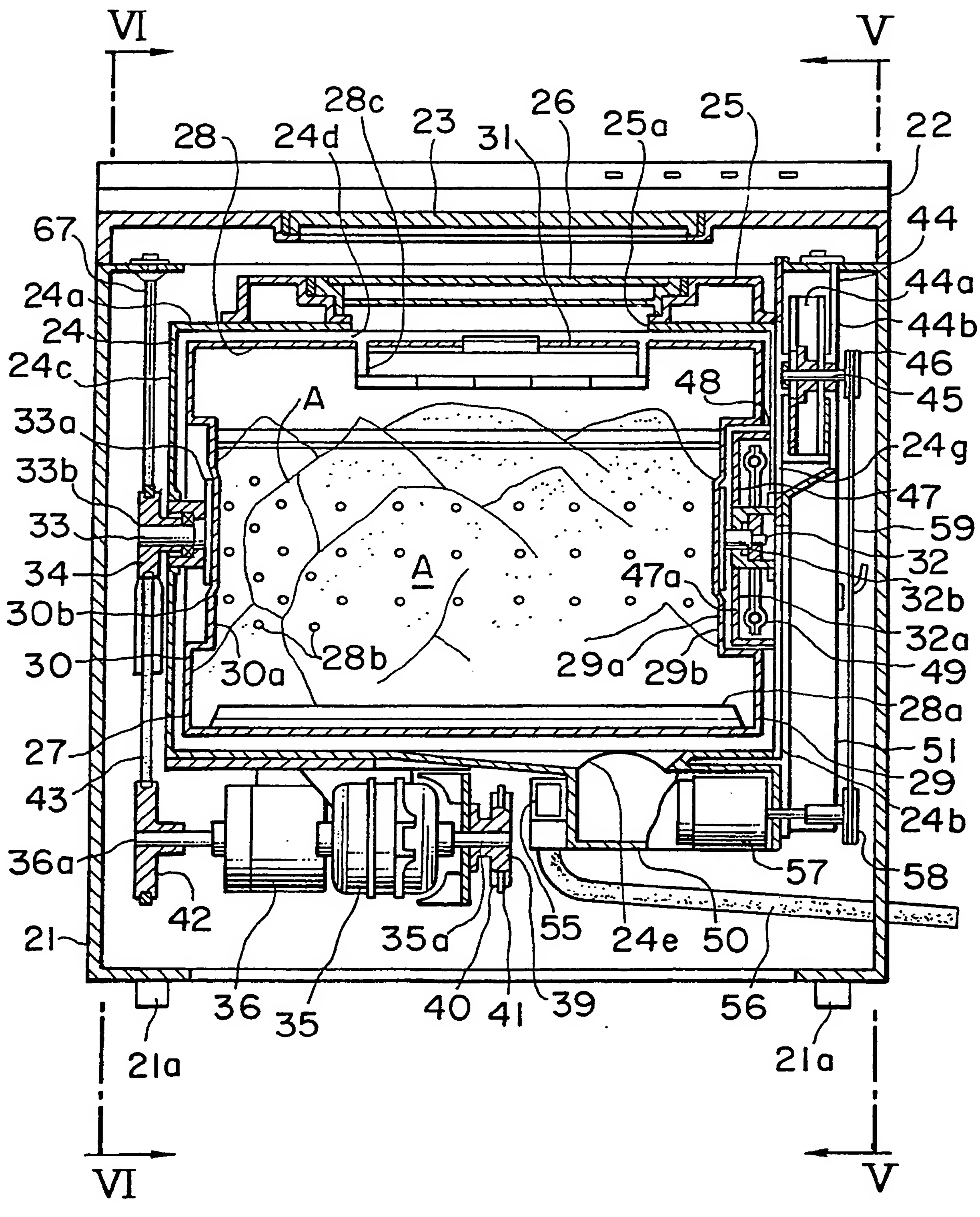

BIBCOCK
OUTER TRANK
24
DRUM LID
31
DRUM
27
FAN
44
SEATHING HEATER
49
52
NOZZLE
51
DUCT
28a
LIFTER
36
SPEED REDUCTION UNIT
35
MOTOR
55
DRAINAGE VALUE
56
DRAINAGE HOSE PIPE

FIG. 4



VI
V
28c
26
25a
25
22
28
24d
23
31
67
44
24a
44a
24
44b
24c
46
48
45
A
33a
24g
33b
47
33
59
A
32
34
47a
32b
30b
32a
30
28b
30a
29a
29b
49
28a
27
51
29
43
24b
36a
57
58
42
21
35a
55
24e
50
36
35
40
41
39
56
21a
21a
VI
V

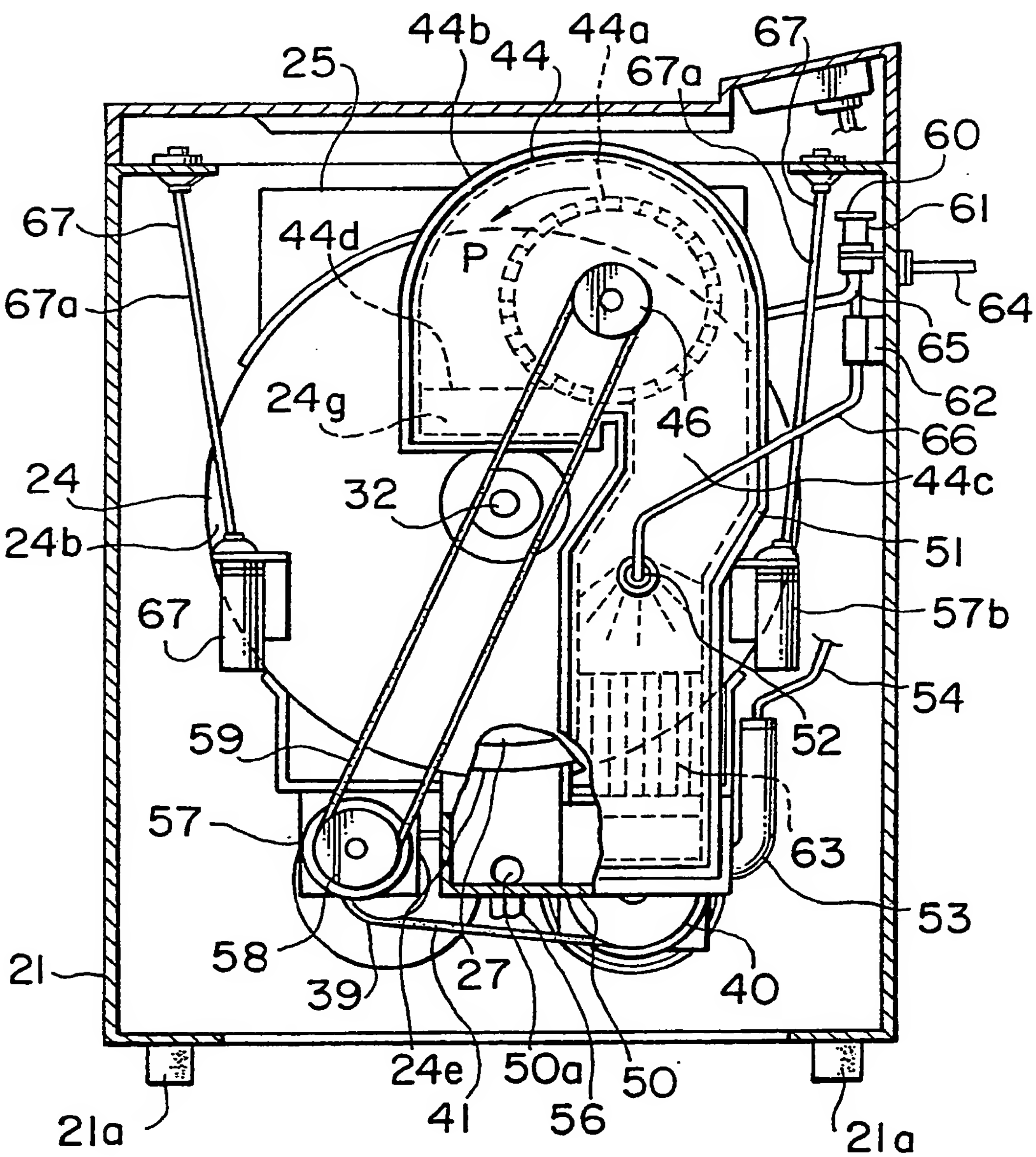
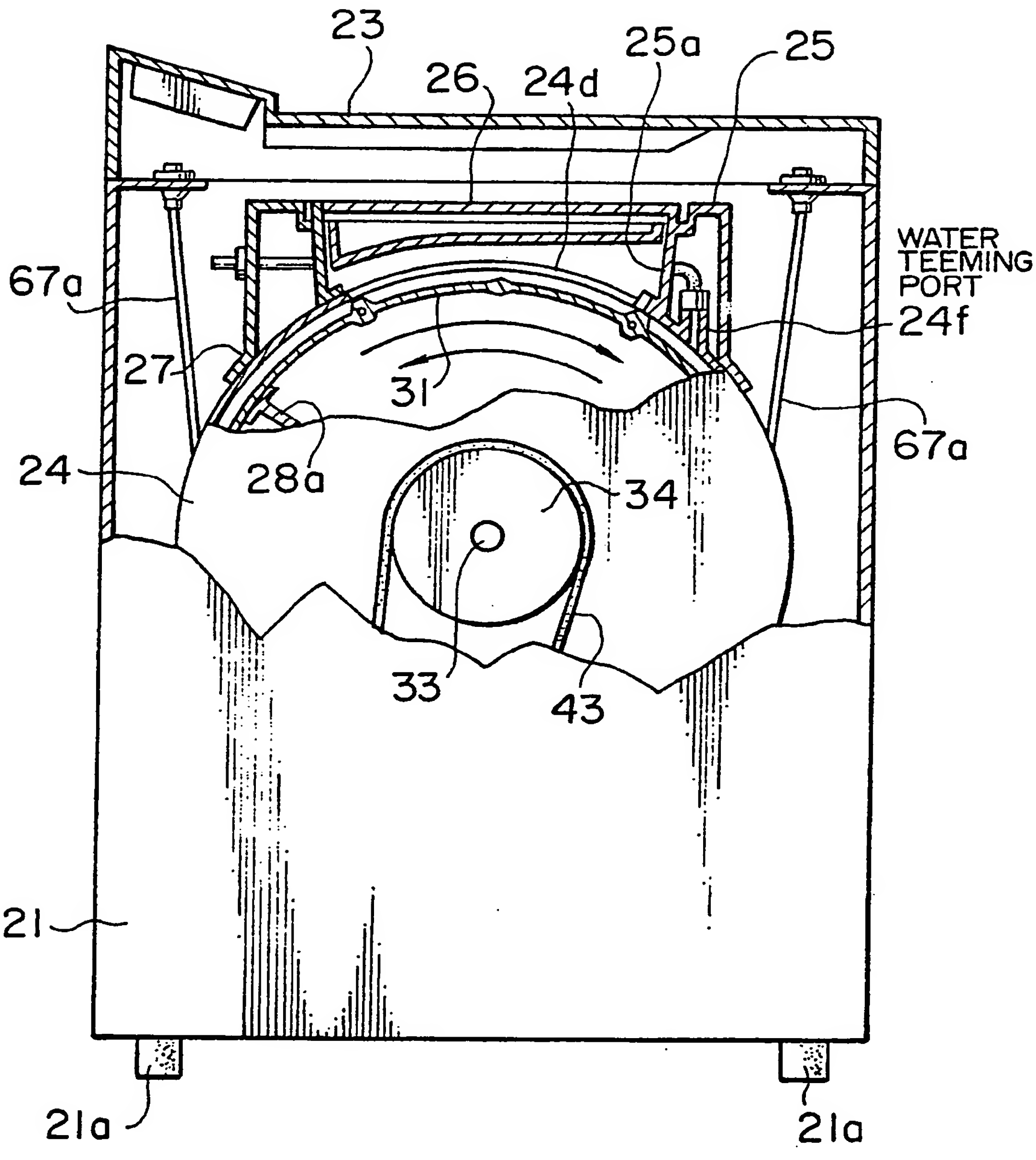

44b
44a
67
25
44
67a
60
61
67
44d
P
64
67a
65
62
24g
46
66
44c
24
32
24b
51
67
57b
54
52
59
57
63
53
58
21
27
40
39
24e
50a
50
41
56
21a
21a

FIG. 5

FIG. 6



23
26
24d
25a
25
WATER TEEMING PORT
24f
67a
27
31
67a
24
28a
34
33
43
21
21a
21a

FIG. 7

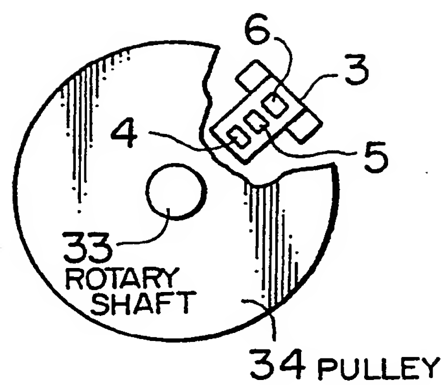


FIG. 8

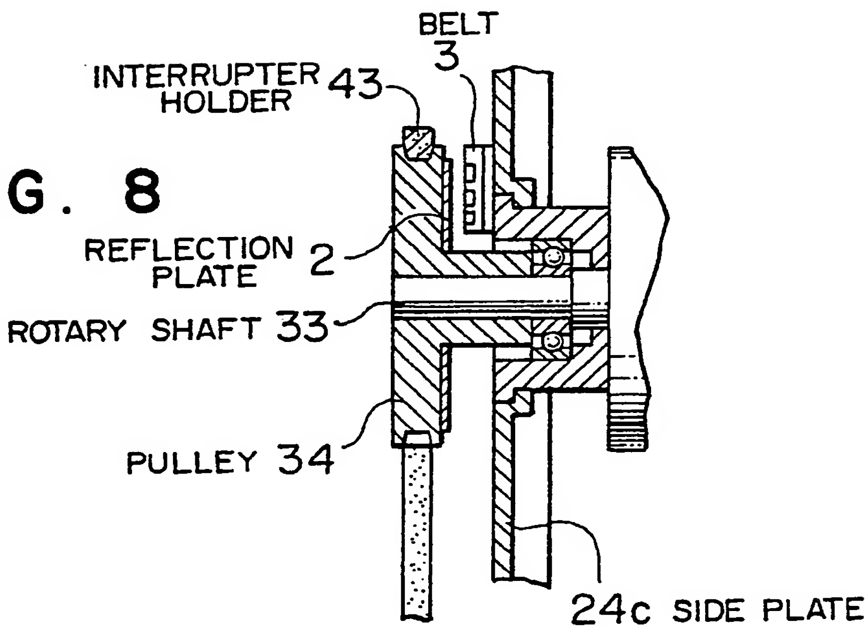


FIG. 9

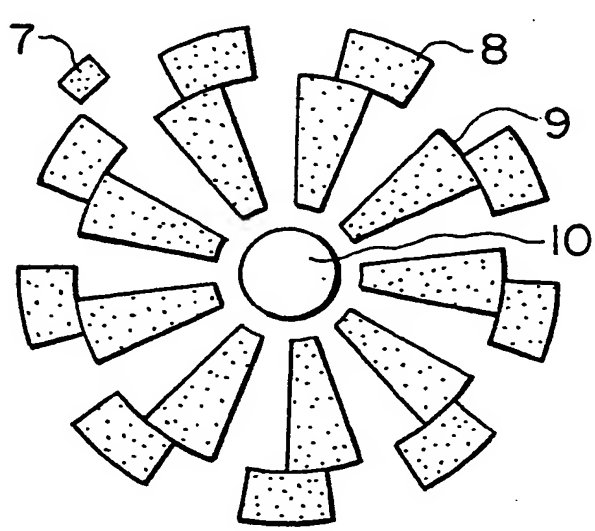


FIG. 10

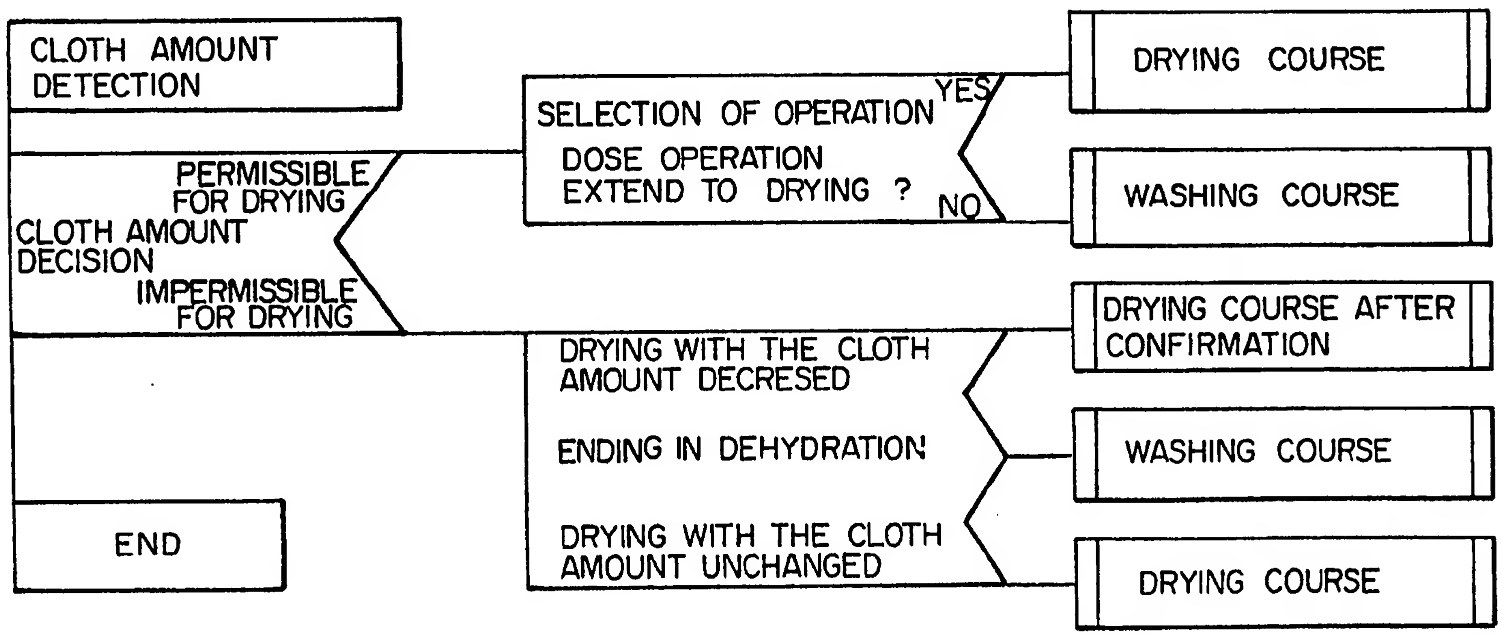

CLOTH AMOUNT DETECTION
PERMISSIBLE FOR DRYING
CLOTH AMOUNT DECISION
IMPERMISSIBLE FOR DRYING
SELECTION OF OPERATION
DOSE OPERATION EXTEND TO DRYING ?
YES
NO
DRYING COURSE
WASHING COURSE
DRYING WITH THE CLOTH AMOUNT DECRESED
ENDING IN DEHYDRATION
DRYING WITH THE CLOTH AMOUNT UNCHANGED
DRYING COURSE AFTER CONFIRMATION
WASHING COURSE
DRYING COURSE
END

FIG. 11

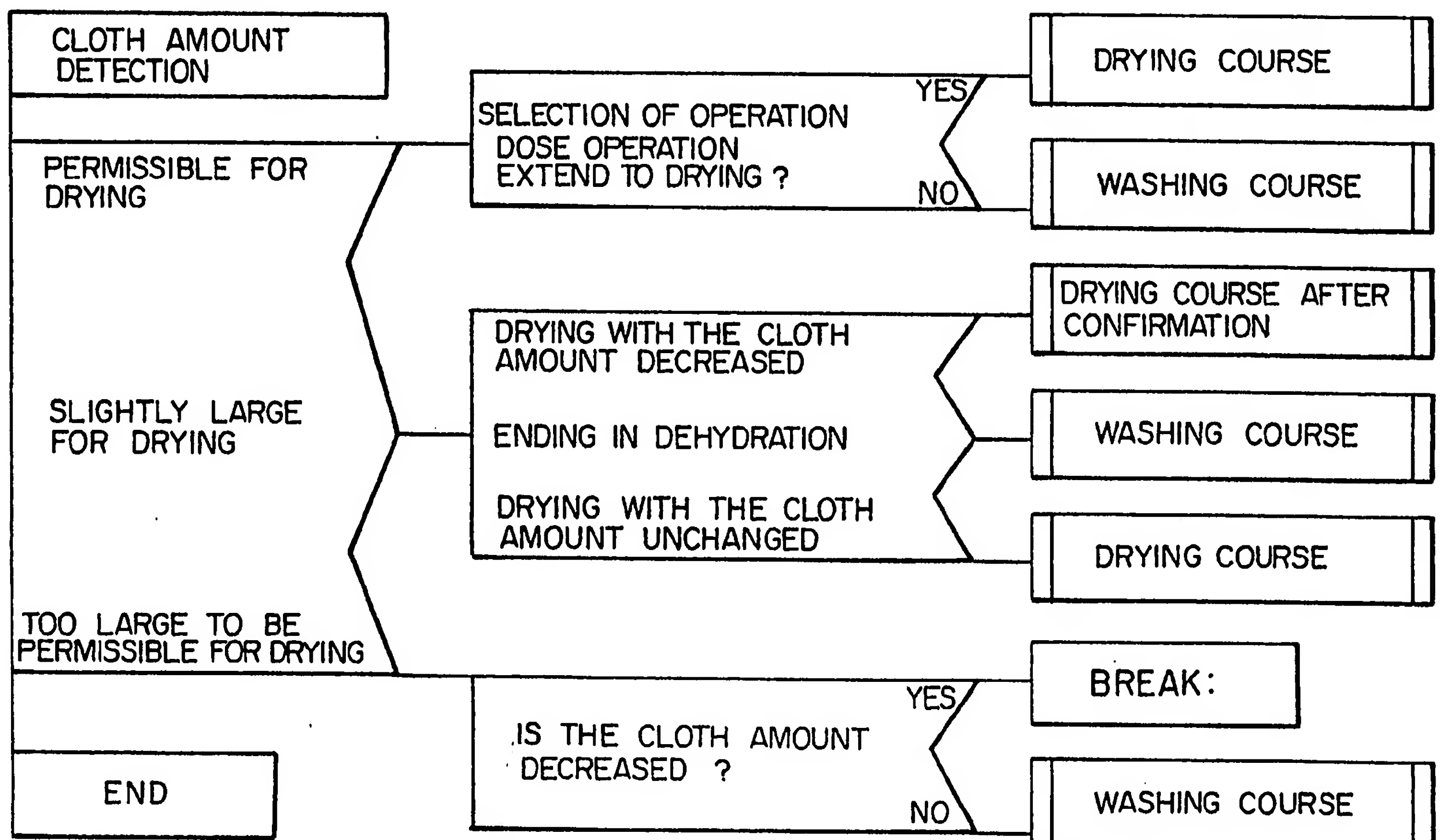

CLOTH AMOUNT DETECTION
PERMISSIBLE FOR DRYING
SLIGHTLY LARGE FOR DRYING
TOO LARGE TO BE PERMISSIBLE FOR DRYING
END
SELECTION OF OPERATION DOSE OPERATION EXTEND TO DRYING ?
YES
NO
DRYING WITH THE CLOTH AMOUNT DECREASED
ENDING IN DEHYDRATION
DRYING WITH THE CLOTH AMOUNT UNCHANGED
IS THE CLOTH AMOUNT DECREASED ?
YES
NO
DRYING COURSE
WASHING COURSE
DRYING COURSE AFTER CONFIRMATION
WASHING COURSE
DRYING COURSE
BREAK:
WASHING COURSE

FIG. 12

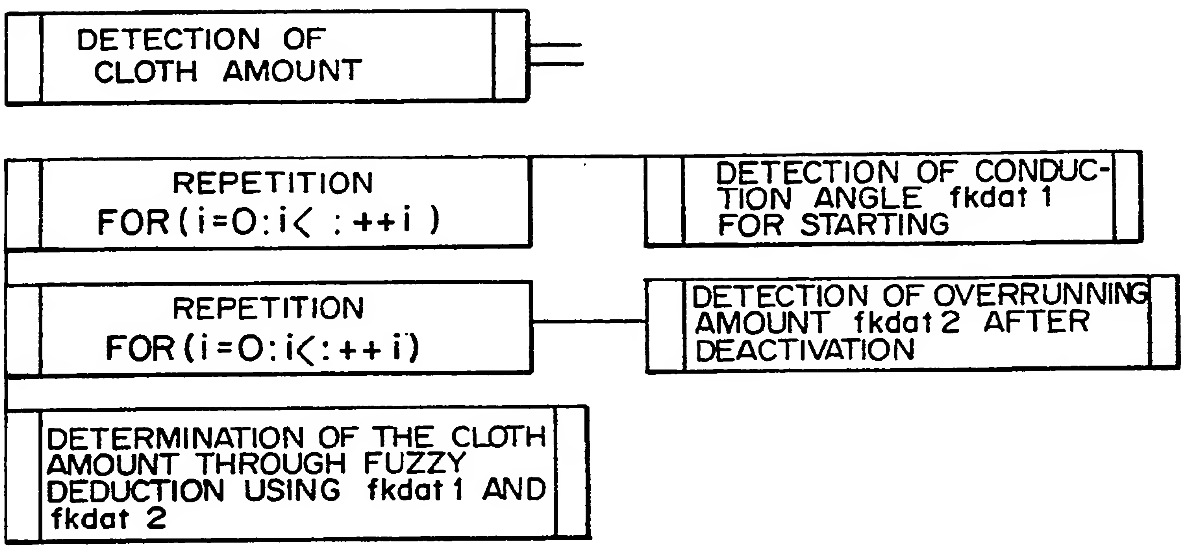

DETECTION OF CLOTH AMOUNT
REPETITION FOR(i=O:i< :++i)
DETECTION OF CONDUCTION ANGLE fkdat 1 FOR STARTING
REPETITION FOR(i=O:i<:++i)
DETECTION OF OVERRUNNING AMOUNT fkdat 2 AFTER DEACTIVATION
DETERMINATION OF THE CLOTH AMOUNT THROUGH FUZZY DEDUCTION USING fkdat 1 AND fkdat 2

FIG. 13

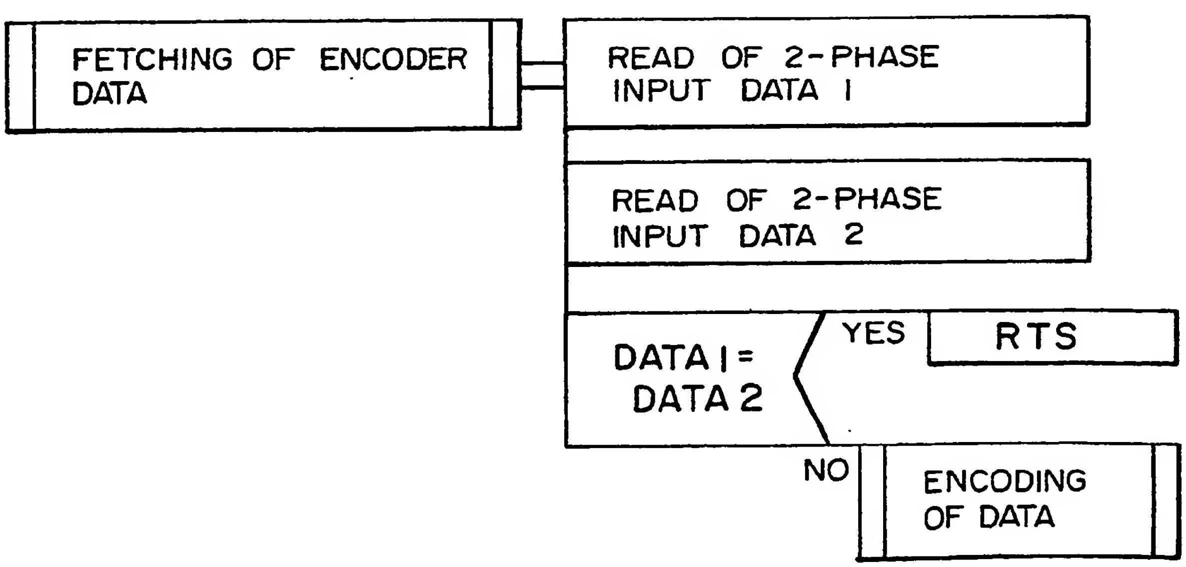

FETCHING OF ENCODER DATA
READ OF 2-PHASE INPUT DATA 1
READ OF 2-PHASE INPUT DATA 2
DATA 1 = DATA 2
YES
RTS
NO
ENCODING OF DATA

FIG. 14

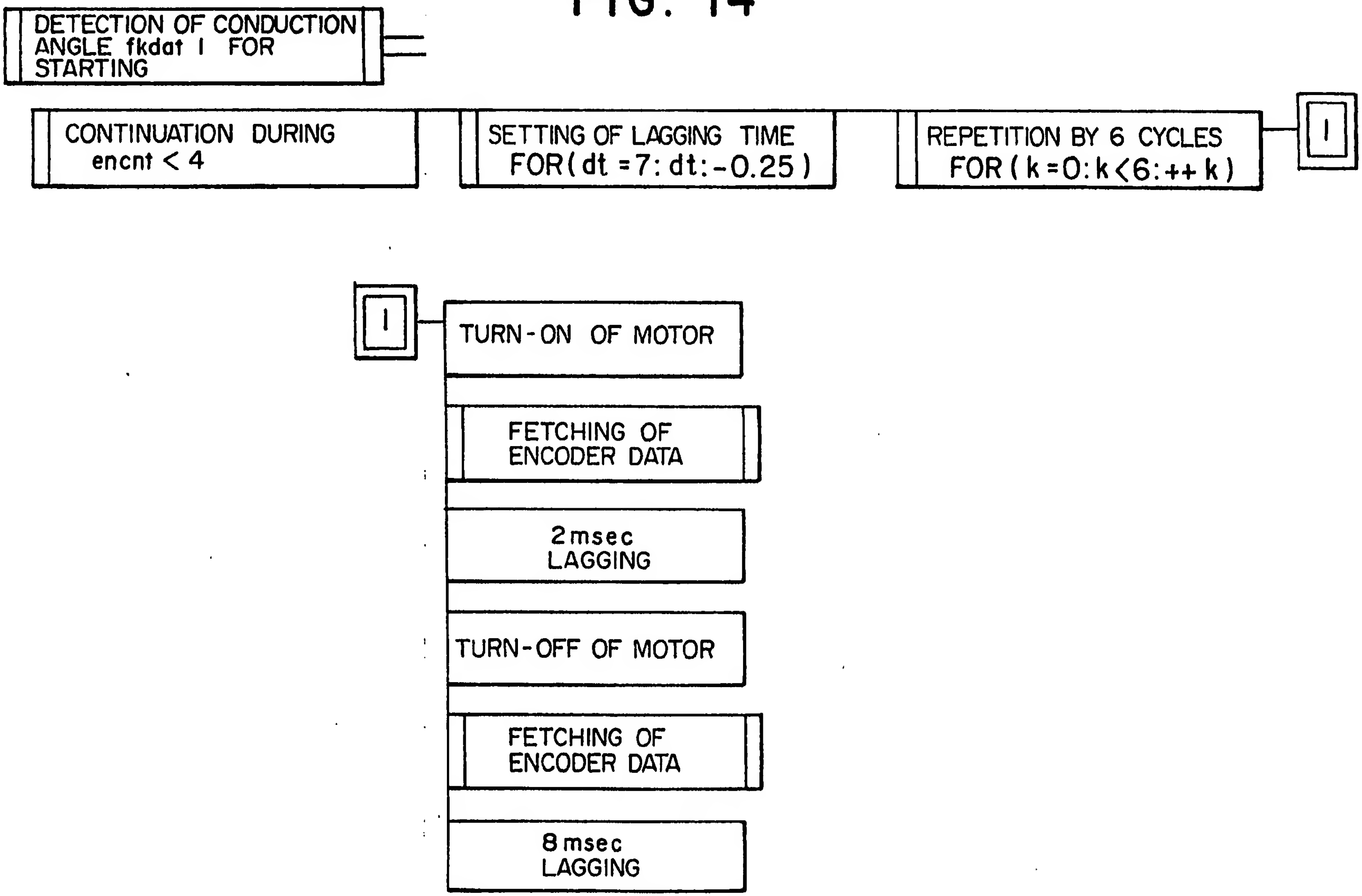

DETECTION OF CONDUCTION ANGLE fkdat I FOR STARTING
CONTINUATION DURING encnt < 4
SETTING OF LAGGING TIME FOR(dt =7: dt:-0.25)
REPETITION BY 6 CYCLES FOR(k=0:k<6:++k)
I
I
TURN-ON OF MOTOR
FETCHING OF ENCODER DATA
2msec LAGGING
TURN-OFF OF MOTOR
FETCHING OF ENCODER DATA
8msec LAGGING

FIG. 15

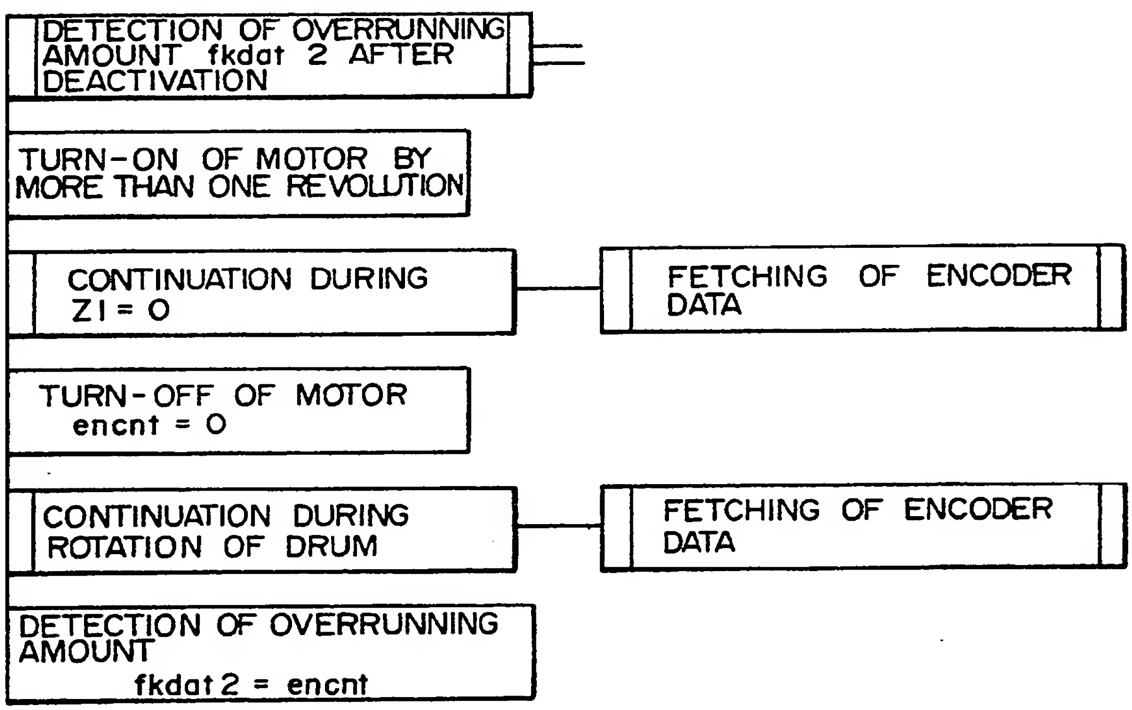

DETECTION OF OVERRUNNING AMOUNT fkdat 2 AFTER DEACTIVATION
TURN-ON OF MOTOR BY MORE THAN ONE REVOLUTION
CONTINUATION DURING Z1 = 0
FETCHING OF ENCODER DATA
TURN-OFF OF MOTOR encnt = 0
CONTINUATION DURING ROTATION OF DRUM
FETCHING OF ENCODER DATA
DETECTION OF OVERRUNNING AMOUNT
fkdat 2 = encnt

FIG. 16A

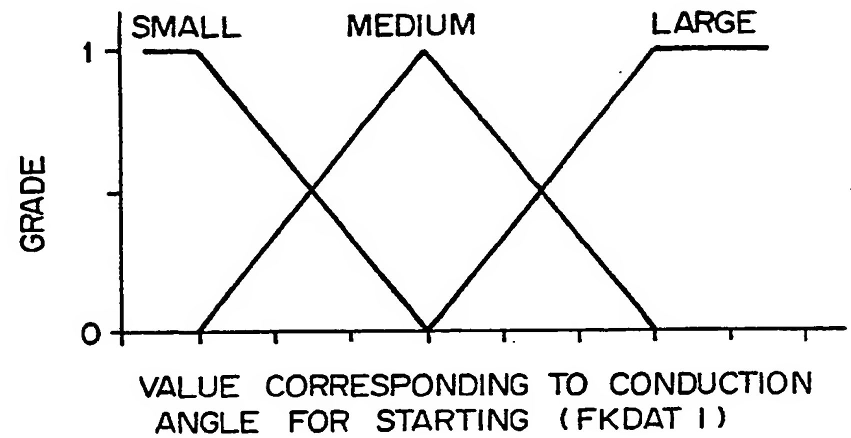


FIG. 16B

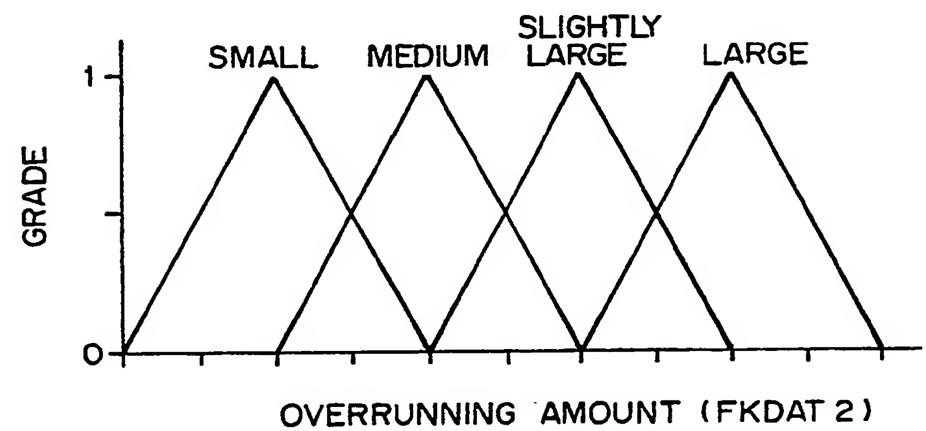


FIG. 16C

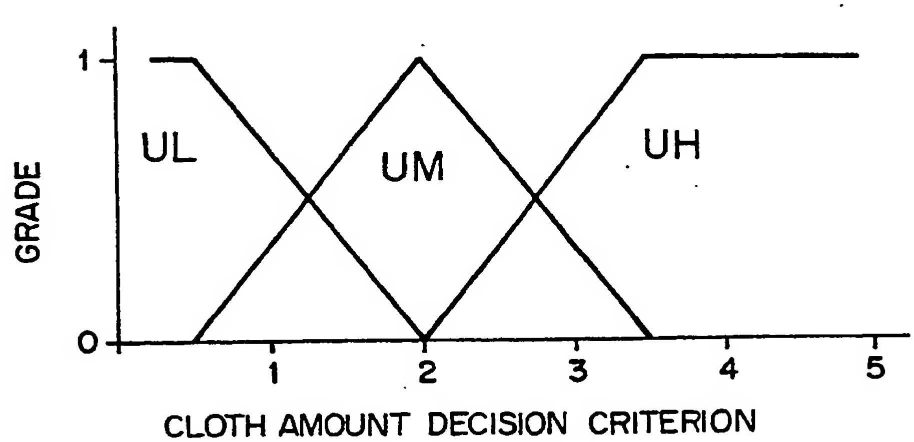


FIG. 17A

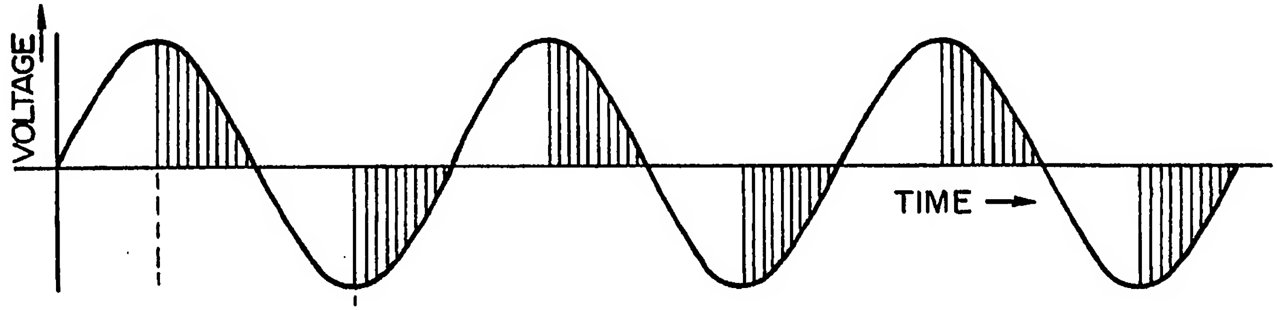


FIG. 17B

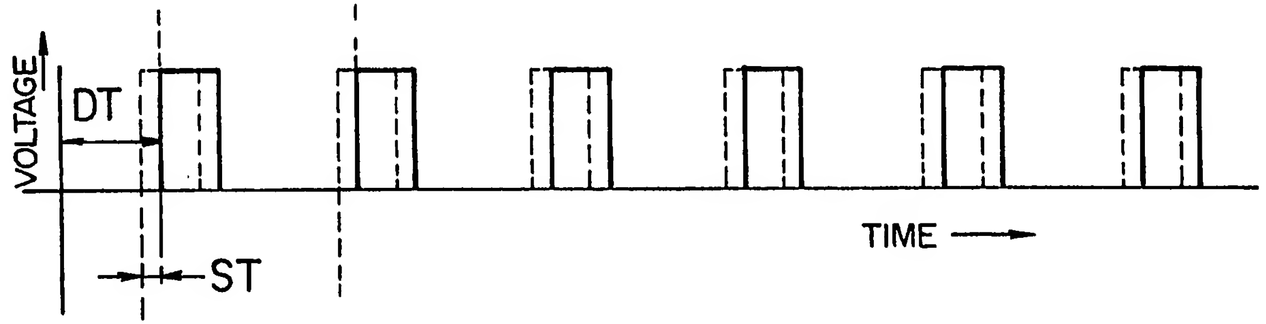


FIG. 17C

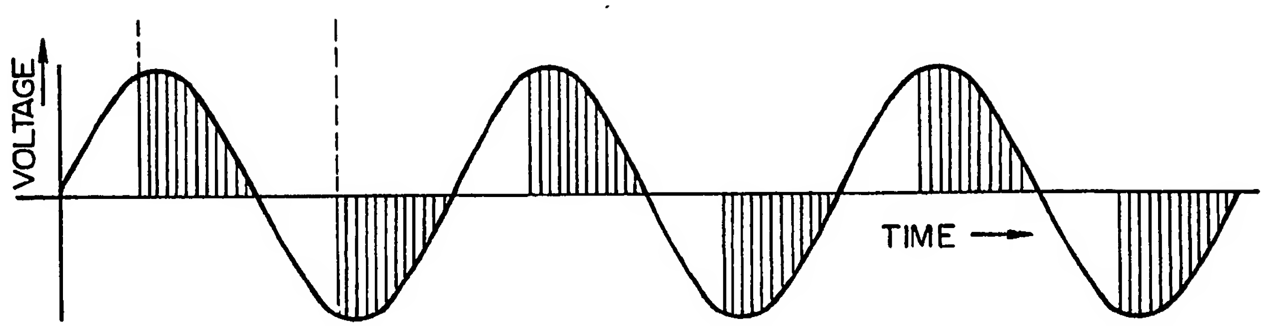


FIG. 18

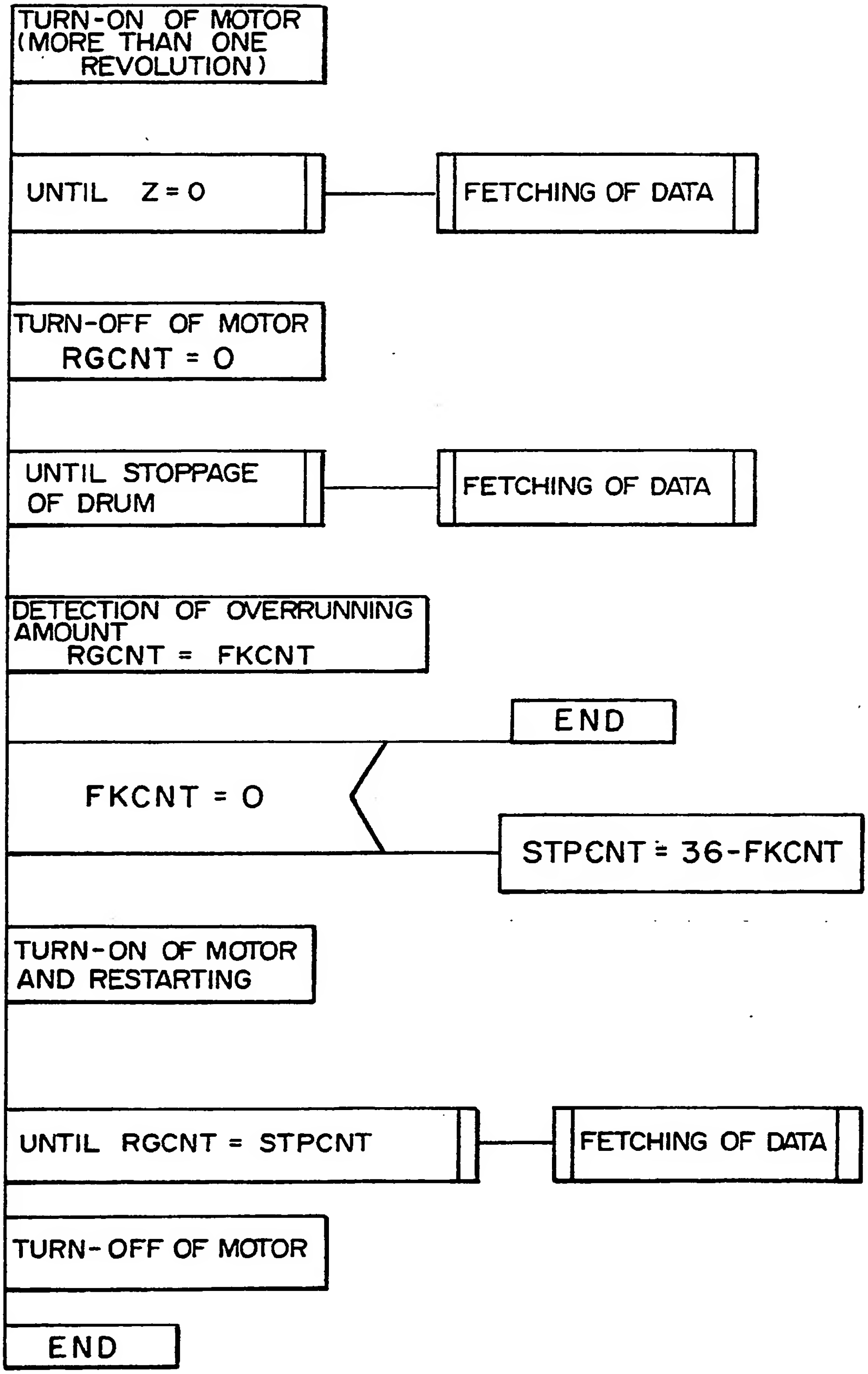

TURN-ON OF MOTOR (MORE THAN ONE REVOLUTION)
UNTIL Z = 0
FETCHING OF DATA
TURN-OFF OF MOTOR
RGCNT = 0
UNTIL STOPPAGE OF DRUM
FETCHING OF DATA
DETECTION OF OVERRUNNING AMOUNT
RGCNT = FKCNT
END
FKCNT = 0
STPCNT = 36-FKCNT
TURN-ON OF MOTOR AND RESTARTING
UNTIL RGCNT = STPCNT
FETCHING OF DATA
TURN-OFF OF MOTOR
END

FIG. 19A

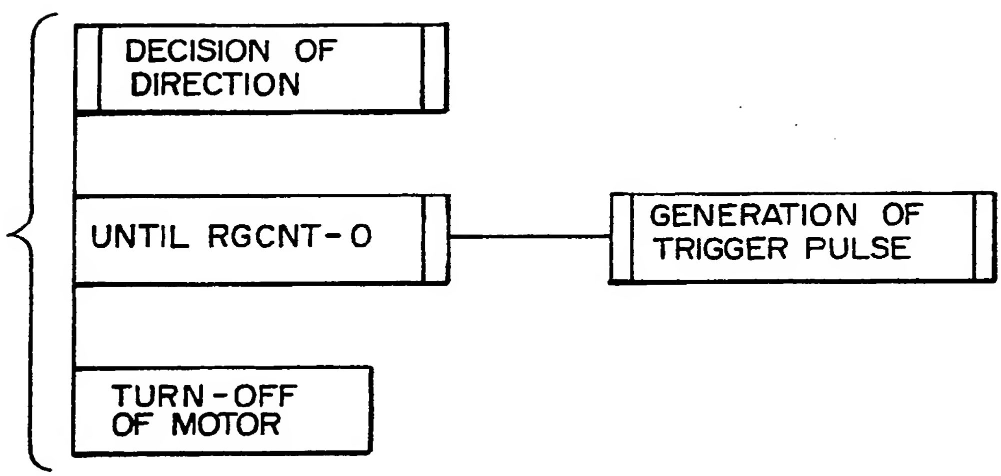


FIG. 19B

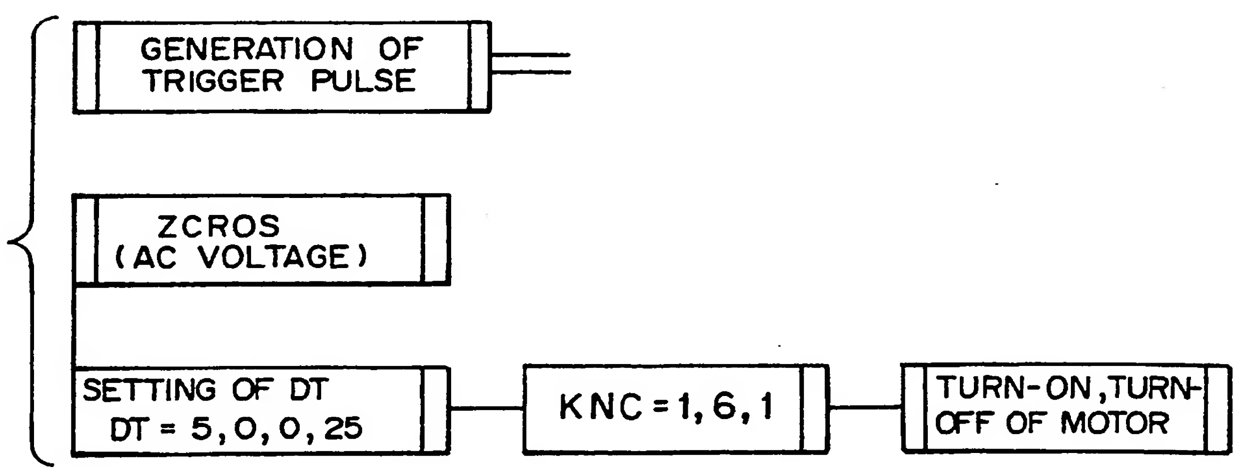
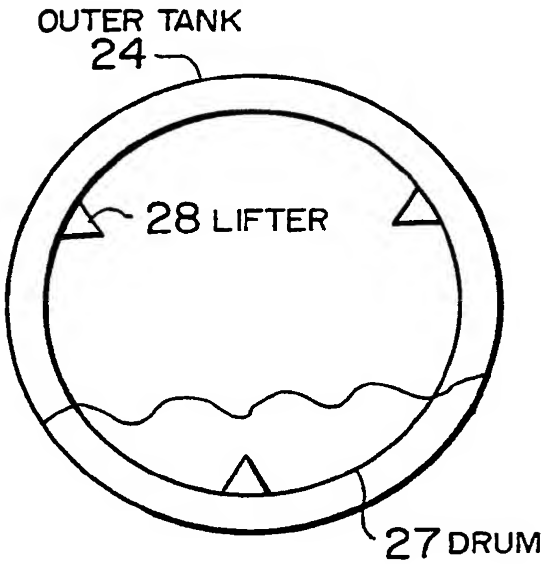
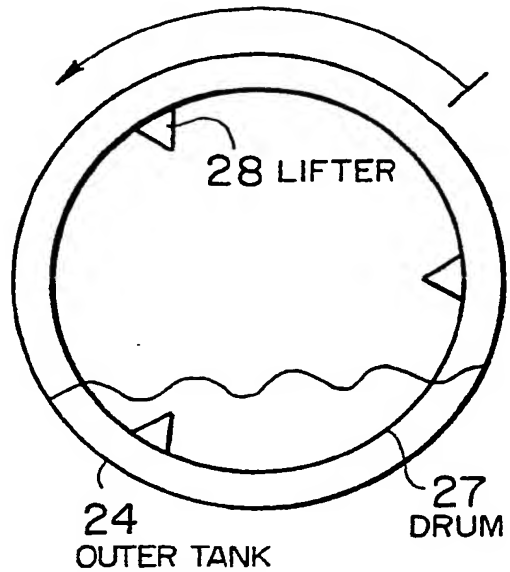


FIG. 20A



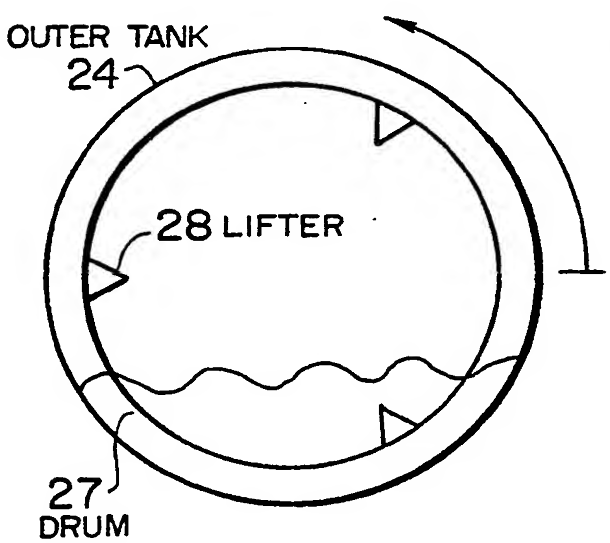
(INITIAL STATE)

FIG. 20B



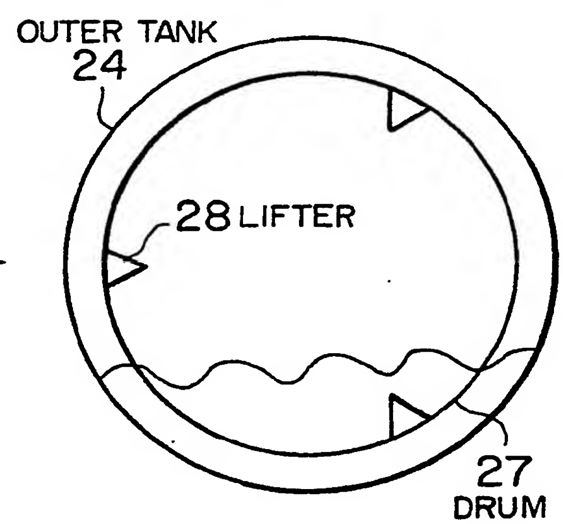
1/4~1/2 REVOLUTION
(FOCIBLE ROTATION)
(DETECTION OF ROTATION ANGLE)

FIG. 20C



(INITIAL ROTATION)
(TURN-OFF OF MOTOR)

FIG. 20D



(INITIATION OF REVERSING)

FULL-AUTOMATED WASHING MACHINE AND FULL-AUTOMATED WASHING AND DRYING MACHINE

The present invention relates to a full-automated washing and drying machine having a drum serving as a container into which cloths are charged and comprised of a cylinder formed with a great number of perforations, and a motor adapted to drive the drum for rotation, whereby water is teemed to cloths charged into the drum, the drum is driven for rotation by means of the motor to perform washing and thereafter dehydration and drying are carried out, to a full-automated washing machine in which the operation extends to dehydration and to a full-automated washing machine and a full-automated washing and drying machine which use a unit for stopping the drum at a home position.

The invention also pertains to washing and drying mechanisms suitable for improving washing and drying performance in the full-automated washing machine and full-automated washing and drying machine.

Conventionally, the following examples of the washing and drying machine provided with cloth amount detector have been available.

(1) In an example described in Japanese Patent Application Laid-open Hei 2-241493, the cloth amount is detected in accordance with the weight of cloths charged in advance of feed of water. If the detected

amount of cloths exceeds a predetermined value, admission to the drying course is inhibited to inform the user that selection of the drying course is not permitted.

(2) In a known example described in Japanese Patent Application Laid-open Sho 62-243588, a value of angular velocity upon start of dehydration and a value of angular velocity upon stop of dehydration of the dehydration tank containing cloths are measured using centrifugal force, the relative magnitude of the cloth amount is decided on the basis of two measured values, and the rinsing time, water flow rate, dehydration time and rotation number which are optimized for the determined relative magnitude are set.

(3) In another known example described in Japanese Patent Application Laid-open Sho 62-176491, the stirring motor is rotated with a lower level of supplied power when detecting the cloth amount than when washing, the magnitude of the amount of cloths is detected on the basis of the rotation number obtained in the course of detection of the cloth amount, a proper water level is automatically determined in accordance with the detected cloth amount, and water feed is carried out.

(4) In another known example described in Japanese Patent Application Laid-open Hei 2-49691, the amount of the washing in the drum is decided on the basis of the difference between an actual amount of water fed to the rotary drum and a reference water feed amount.

(5) In a still another known example described

in Japanese Patent Application Laid-open Hei 1-274797, fuzzy deduction is carried out on the basis of information from sensors for detecting the state of the washing so that the washing condition such as washing time may be set.

Further, conventional techniques for stopping the drum at the home position in the cloth drying machine or the full-automated washing machine and full-automated washing and drying machine are available as follows:

(6) As described in Japanese Patent Application Laid-open Sho 63-260594, there is provided a rotational position detector for detecting the position of the drum and when waiting time determined on the basis of the period of rotation of the drum has elapsed following arrival of the drum at a reference position, electromagnetic braking is applied to the motor for driving the drum to stop the same,

(7) As described in Japanese Patent Application Laid-open Sho 63-260599, a rotational position detector for the drum is provided and when the drum is not at a predetermined position, it is so controlled as to be once rotated in the reverse direction and thereafter in the forward direction, and

(8) In the drum type washing machine, as described in Japanese Patent Application Laid-open Sho 64-2690 and Japanese Patent Application Laid-open Sho 64-2691, the rotation angle of the drum is detected by means of

a plurality of switches provided at predetermined angular intervals.

In the conventional machine which automatically goes through washing and dehydration of drying,

(9) As described in Japanese Patent Application laid-open Hei 1-166799, the drum serving as the washing tank, dehydration tank and drying drum and formed with a great number of perforations is supported horizontally by means of bearings, and lifters extending radially are formed on the inner peripheral surface of the drum, whereby when washing, the drum is filled with washing water up to an upper portion thereof and forward/ reverse rotation of the drum is alternately repeated reiteratively at a short period. When drying, the drum is operated in a similar way.

Disadvantageously, the prior art set forth so far do not fully take into consideration the following points: In example (1), either washing course or drying course is automatically set by simply deciding in accordance with the weight of cloths whether drying is permissible or not. Therefore, even when, for example, the washing is allowed to be slightly wrinkled in consideration of a variety of conditions, for example, quality of cloths, the drying course cannot be selected. Accordingly, the user cannot at all determine, at will, the operation which extends to drying. Further, this prior art in no way discusses display of the results of decision of cloth amounts in

advance of teeming water and operation/input means for selecting the next operation in advance of teeming water, so that decision by the cloth amount detector cannot be used as auxiliary information which is utilized by the user who decides as to whether the operation should end in dehydration following washing or whether the operation should extend to drying.

In example (2), due to the fact that the angular acceleration represents a change in rotation number with time, a variation in rotation number due to a variation in the cloth amount is small as described on page 2 of Japanese Patent Application Laid-open Sho 62-176491 and therefore this prior art is unsuitable for detection of cloth amounts with high accuracies.

In example (3) of rotation number detection type, even if the stirring motor is operated with a low power level, the influence of frictional loss in mechanism components cannot be avoided and highly accurate cloth amount detection cannot be expected.

In the full-automated washing and drying machine which extends to drying operation, the amount of the washing permissible for good drying finish removed of wrinkle is in general smaller than the amount of the washing subject to only washing without undergoing drying. Therefore, when the washing is charged into the washing tank to start washing, it is important to decide whether the amount of the washing charged is permissible for obtaining the satisfactory finish

state even when the operation extends to drying or the amount of the washing charged is permissible only for washing but is not expected to permit the satisfactory finish state.

In (4) example, even when it is known that the amount of cloths wetted by water feed is impermissible for drying, the cloth amount cannot be detected without feeding water, and the cloth amount is difficult to decrease, thus impairing ease of operation of the full-automated washing and drying machine.

In (5) example, only the washing condition is set and decision as to whether the cloth amount is permissible for drying or not cannot be carried out. The cloth amount is merely one of input values for fuzzy deduction. This prior art fails to take into consideration the ease of operation and the accuracy of cloth amount detection.

In addition, the aforementioned techniques for home position stoppage have the following disadvantages.

In (6) example, the halt position of the drum varies greatly not only with the off timing for the drum drive motor and the magnitude of load prevailing after the application of electromagnetic braking but also with, as described in Japanese Patent Application Laid-open Sho 62-243588, the frictional loss. Especially, in the drum type washing machine, the rotation angle of the drum greatly varies with the load as described

in Japanese Patent Application Laid-open Sho 62-2691.

In example (7), when the drum is not at the predetermined position, it is once rotated in the reverse direction and thereafter in the forward direction. In this operation, however, the time lapse preceding the home-position stoppage is unstable as described on page 3 of Japanese Patent Application laid-open Sho 63-260594; especially, when a four-pole capacitor induction motor which rotates at a single speed is used to drive the drum, oscillation will be liable to occur without the provision of a dead zone due to frictional loss.

In example (8) of drum type washing machine, the detection of the drum rotation angle by means of a plurality of switches tends to suffer from a problem that distriction between forward rotation and reverse rotation is difficult to achieve. In the full-automated washing and drying machine, rotational positions and stop position of the drum can be detected with the same rotational position detector more inexpensively than with a plurality of rotational position detectors.

In example (9) of prior art directed to improvement of washing and drying performance, when the cloth amount is small, the machine can operate satisfactorily but as the load on the motor becomes excessive, the rotation angle per period is decreased and necessary washing power cannot be obtained. Further, the forward and reverse rotation angles are the same and symmetrical

with each other, raising a disadvantage that the washing is always rubbed at the same portion and there results great washing non-uniformity. Similarly, drying non-uniformity tends to occur when drying.

An object of the present invention is to provide a full-automated washing machine and a full-automated washing and drying machine which can solve the prior art problems to ensure ease of operation by promoting convenience of a man-machine interface system and to improve detection accuracy by avoiding the influence of frictional loss in mechanism components and which has a cloth amount detector capable of detecting the amount of cloths in their dry state without wetting them and uses a drum home position stopping unit capable of solving problems encountered in the conventional drum home position stopping technique, whereby the prior art problems raised in connection with the washing and drying performance can be eliminated to improve the washing and drying performance.

To accomplish the above object, according to the invention, the cloth amount is detected at the time that the operation is started by charging the washing into a drum serving as a container in advance of teeming water, the cloth amount is decided as to whether to be permissible for drying or not and a decision result is displayed in advance of teeming water, and the user is

urged to select any one of washing, rinsing, dehydration and dry processes by means of operation/input means in advance of teeming water, thereby permitting operations under various conditions (the kind of cloths, the manner of laying cloths and ambient circumstances).

Further, the operation is decided as to whether to extend to drying or not in terms of at least three steps inclusive of fuzziness to ensure selection of any one of washing and drying processes even under a variety of conditions of cloths. Similarly, if the decision determines that the cloth amount should be decreased, if possible, for the purpose of sufficient drying, either the operation (course) which ends in dehydration following washing or the operation (course) which extends to drying can be carried out by selectively triggering automatic setting means; and if the cloth amount goes beyond a value permissible for drying to a great extent, execution of the drying process is inhibited.

In detecting the cloth amount, the drum serving as the container is once started and subsequently the power supply for the motor is turned off to cause the drum to continue rotating by inertia and then stop, so that a value corresponding to an overrunning amount of the drum may be determined; and in addition, the motor adapted to drive rotation of the drum is supplied, upon starting, with power which gradually varies from a low level to a high level and when a rotational position

detector carried on the rotary shaft of the drum detects start of the drum, a value corresponding to a level of power supplied at that time (a minimum level of power necessary for starting the motor) is determined. Then, a decision criterion for cloth amount is determined on the basis of the two values. Supply of power may be controlled by controlling the angle of electric conduction (conduction angle) of AC power supplied to the motor.

The decision criterion for the magnitude of cloth amount in the container may be determined by a plurality of selected values which are substantially proportional to at least the cloth amount. For example, one value is proportional to the weight of cloths and determined by detecting strain in shock absorbers for buffer supporting the weight of the container, by means of a strain gauge. The other value is proportional to the moment of inertia of cloths and determined by detecting by means of the rotational position detector an overrunning amount generated when the drum is rotated, deactivated once and overrun in the direction of rotation after the deactivation. Then, fuzzy deduction is carried out using the thus defined two values in the conditional part to provide a decision criterion for cloth amount. Other values than the above may be used suitably in combination in the conditional part, including a value representative of electromotive force due to pressure detected by a piezoelectric sensor as in the

case of detection of the weight, a value representative of the height of the cloths in the container and detected by means of an ultrasonic sensor, and a value represented of a quantity corresponding to a minimum level of power necessary for starting the container (drum).

Especially, by using in the conditional part a first value which is substantially proportional to the moment of inertia of cloths and frictional loss in mechanism components and a second value which is substantially proportional to the moment of inertia and is in inverse proportion to the frictional loss so that the influence of the moment of inertia and that of the frictional loss are cancelled out, fuzzy deduction is carried out to provide a decision criterion for cloth amount.

Further, in order to attain the purpose associated with the home position stopping technique, when the drum is rotated and once deactivated, an overrunning amount, in the rotation direction of the drum, due to inertial force by the load prevailing at that time and frictional loss in the shaft are detected by means of the rotational position detector. Then, when the drum is restarted for rotation, a halt signal is subsequently applied to the drum drive motor at a timing which is modified by a reference position detectable by the rotational position detector and corresponding to the position of the lid.

By this, repetitive correction of the difference

between stop position and reference position can be disposed with which is effected by driving the motor in the forward and reverse directions alternately on the bais of signals from the rotational position detector. But, in order to improve accuracy of stop position of the drum, a so-called soft starting process (described in, for example, "Power Control Circuit Design Know-how" by Arita and other two, CQ Shuppan Sha, pages 54 and 127, 1985) is employed wherein the direction of drive is decided on the basis of the difference from the reference position, the drive motor is started by bringing it to on-state from off-state in relation to the AC power supply at a conduction angle of about 30 degrees corresponding to a low power level and thereafter the conduction angle is gradually increased.

The rotational position detector may be realized with an incremental type or absolute type encoder to accurately pick up forward and reverse rotations of the drum, thereby controlling the rotation angle of the drum during washing and drying or low speed dehydration.

In order to attain the purpose associated with improvement of the washing and drying performance, according to the invention, the rotational position detector for the drum is provided, the drum is rotated in forward and reverse directions alternately at a short period or cycle while detecting the rotation angle of the drum, wherein the sum of an interval of time for

driving (forcible rotation) while detecting the rotation angle of the drum and an interval of time for deactivated rotation (inertial rotation) which ends at the inversion of rotation is made to be asymmetrical by assuming different values in the forward and reverse directions.

According to the invention, the amount of cloths in dry condition is detected, in advance of teeming water, at the time that the washing is charged into the drum, and either an indication purporting that the cloth amount is small enough to permit the operation to extend to drying following washing and dehydration or an indication purporting that the cloth amount is permissible for washing and dehydration but is too large to permit the operation to extend to sufficient drying is displayed to inform the user of the indication. Then, the user is allowed to decide as to whether the operation should extend to drying or whether the operation should end in dehydration through washing and rinsing, so as to select the mode of operation, thus preventing inconvenience that, for example, even when the selected operation extends to drying with the cloth amount decreased, cloths decreased in amount will suffer from wet finish or inconvenience that even when the operation expected to extend to drying is started, the operation is forced to automatically end in dehydration.

Further, the decision as to whether the cloth amount is permissible for drying or not is displayed in

terms of three steps and therefore the freedom of selection of the washing and drying courses predominates to allow the user to determine one of various operations at will, thus making a contribution to improvement of ease of operation. Accordingly, the will of the user is involved in automatic setting for the thus selected course and a highly convenient man-machine interface system can be realized.

According to the invention, in the cloth amount detection, it is possible to detect whether a change in the rotation overrunning amount of the drum after turn-off of the motor power supply is due to a change in the moment of inertia of the drum and cloths (a change in the cloth amount) or due to a change in frictional loss in mechanism components of the motor adapted to drive the drum. More specifically, the value corresponding to power supplied for starting the motor adapted to drive the drum (minimum power necessary for starting) increases in proportion to the magnitude of moment of inertia of the drum and cloths and the magnitude of the frictional loss, and the overrunning amount of the drum after turn-off of the motor power supply increases in proportion to the magnitude of moment of inertia of the drum and in inverse proportion of the magnitude of the frictional loss. As is clear from the above, since the moment of inertia equally affects the value corresponding to power supplied for starting and the value corresponding to the overrunning amount of

the drum after turn-off of the motor power supply but the frictional loss conflictly affects these values, only the influence of the moment of inertia, that is, a change in the cloth amount can be detected without being disturbed by interference with the frictional loss. Therefore, the cloth amount can be detected even in dry condition in which high accuracy of detection is required. By supplying power under the control of the conduction angle for the motor AC power supply, the value corresponding to a minimum power level nececsary for starting can be determined in an easy and simple manner.

By using the decision criterion for cloth amount obtained through fuzzy deduction which uses in the conditional part values having relation to the cloth amount and obtained by a plurality of means, highly accurate cloth amount decision can be effected which is removed of the influence of disturbance factor other than the cloth amount and which is adaptive to changes in ambient conditions.

Further, by using the decision criterion for cloth amount obtained through fuzzy deduction based on the aforementioned two values for which the influence of the moment of inertia and the influence of frictional loss in mechanism components are cancelled out, proper decision of cloth amount can be carried out which can exclude the influence of frictional loss and which can take into account changes in ambient conditions such

as temperature and humidity, the manner of laying cloths and experience of the user.

In accordance with the aforementioned home position stopping technique, after deactivation of the drum, a value of the overrunning amount of the drum is once detected. Subsequently, the drum is restarted for rotation and a halt signal based on the previously detected overrunning amount value is applied. As a result, the lid of the drum can be stopped at the reference position and the error in the stop position can be controlled approximately to the resolution of the rotational position detector.

Repetitive corrections after deactivation of the drum can be dispensed with, the time lapse preceeding the home-position stoppage becomes stable and for any frictional loss and load, oscillation will not be liable to occur.

Further, the rotation angle is detected during washing and drying or dehydration at low speed by using the same rotational position detector as that used for detection of stoppage of the drum and especially when forward and reverse rotation angles of the drum to be detected by means of an encoder (rotational position detector) are represented in terms of random number, washing power which does not depend on the load can be obtained, making it possible to provide a full-automated washing and drying machine which can be reduced in washing non-uniformity, dehydration non-uniformity and

drying non-uniformity.

In addition, in accordance with the aforementioned technique for improving the washing and drying performance, the rotation angle is controlled and hence forward/reverse rotation of the drum during washing and drying can be carried out steadily for any load amount, thus making a contribution to improvement of washing performance; and besides, the location of the washing can always be moved inside the drum, providing a full-automated washing and drying machine of less washing non-uniformity and drying non-uniformity.

Preferred embodiments of the present invention will now be described by way of example, with reference to the accompanying drawings, in which:-

Fig. 1 is a block diagram showing the construction of a controller of a full-automated washing and drying machine according to the invention;

Fig. 2 is a schematic perspective view showing the full-automated washing and drying machine;

Fig. 3 is a selective, schematic longitudinally sectional view showing a section participating in drying;

Fig. 4 is a longitudinally sectional view showing the overall construction of the full-automated washing and drying machine;

Fig. 5 is a sectional view taken on the line X-X of Fig. 4;

Fig. 6 is a sectional view taken on the line Y-Y of Fig. 4;

Fig. 7 is an enlarged front view, partly

exploded, showing a rotational position detector shown in Fig.1;

Fig. 8 is an enlarged fragmentary sectional view of the Fig. 7 rotational position detector;

Fig. 9 is a diagram illustrating patterns on a reflection plate 2;

Fig. 10 is a problem analysis diagram (PAD) showing an example of operation where decision of the cloth amount is carried out through two steps;

Fig. 11 is a PAD showing another example of operation where the cloth amount decision is carried out through three steps;

Fig. 12 is a PAD showing the outline of a cloth amount detection system;

Fig. 13 is a PAD showing the operation of an encoder serving as the rotational position detector;

Fig. 14 is a sechematic PAD showing the manner of determining a value corresponding to a conduction angle for starting;

Fig. 15 is a schematic PAD showing the manner of determining an overrunning amount upon deactivation;

Figs. 16A to 16C are diagrams showing membership functions of the value corresponding to the conduction angle for starting, the value of overrunning amount and the decision criterion for cloth amount, respectively;

Figs. 17A to 17C are waveform diagrams useful to explain conduction angle control;

Fig. 18 is a schematic PAD showing the manner of stopping the drum at a home position;

Figs. 19A and 19B are schematic PAD's showing modifying methods for improving accuracy of stop position; and

Figs. 20A to 20D are schematic diagrams showing the manner of operating the drum.

In the accompanying drawings, Fig. 1 is a block diagram showing the construction of a controller, Fig. 2 is a perspective view schematically showing a full-automated washing and drying machine according to the invention, Fig. 3 is a selective schematic diagram showing a section principally participating in drying, Fig. 4 is a longitudinally sectional view showing the overall construction of the full-automated washing and drying machine according to the invention, Fig. 5 is a sectional view taken along the line X-X of Fig. 4 and Fig. 6 is a sectional view taken along the line Y-Y of Fig. 4.

In these Figures, an outer frame 21 serving as a housing is supported on rubber legs 21a, a top cover 22 is comprised of a unitary structure of a control board for accommodating the controller and a cover and is fixedly secured to the outer frame 21, and a lid 23 is hinged to the cover.

An outer tank 24 is constructed of a cylinder 24a and side plates 24b and 24c. The cylinder 24a is formed at its upper peripheral portion with an opening 24d for change/discharge of the washing, as designated by A, and at its lower peripheral portion with a draingage port 24e. A water teeming port 24f is attached to an upper peripheral portion of the cylinder 24a. The side plate 24b is formed, near its center, with an opening 24g through which air is sent to a drum 27 during drying. The outer tank supports, at the centers of the side plates 24b and 24c, the drum 27 through bearings and contains washing water.

A tank cover 25 has an opening 25a the wall of which engages the periphery of the opening 24d in the outer tank 24 to secure the tank cover 25 to the outer tank 24, and an outer tank lid 26 is hinged to the tank cover 25. The drum 27 has a dual function of washing tank and dehydrating tank and at the same time serves as a drying container. The drum 27 is constructed of a cylinder 28 and side plates 29 and 30.

A plurality of lifters 28a are provided on the inner periphery of the drum 27 at equal intervals and they extend radially, in order that washing operation can be carried out while exerting an impact to the washing A during washing and drying operation can be carried out while stirring the washing A during drying. Small perforations 28b of a diameter of 4 to 6 mm act as dehydration holes during dehydrating operation

and also act as exhaust holes for wet air during drying operation.

These small perforations 28b are formed over the entire periphery of the drum 27 such that they are thin on the hot-air blowing side and dense on the opposite side. The drum 27 is partly cut and opened to form a charge port 28c for charge/discharge of the washing A, and a drum lid 31 is hinged to the peripheral edge of the charge port 28c.

The side plate of drum 27, which is on the hot-air blowing side during drying, has its central portion formed into a recess 29a the outer periphery of which is of an annular plane and formed with a number of small perforations for hot-air blowing. The side plate 30 is arranged opposite the side plate 29, having the same shape as that of the side plate 29, and formed with a recess 30a and small perforations 30b for wet air exhaust.

A rotary shaft 32 is comprised of a unitary structure of a hub 32a secured to the side plate 29 of the drum 27 and a shaft 32b, and a rotary shaft 33 is comprised of a unitary structure of a hub 33a secured to the side plate 30 and a shaft 33b fixedly mounted with a pulley 34. The pulley 34 is adapted to drive the drum fixed to the shaft 33b.

A four-pole capacitor induction motor 35 is adapted to drive the drum 27 and it is fixedly mounted to the bottom of the outer tank 24. During washing

and drying, the motor 35 is driven to rotate the drum 27 forwardly and reversely through a speed reduction unit 36. During dehydration, the motor is first rotated at a low speed and thereafter it is not subjected to speed reduction but is rotated at a high speed.

Like the motor 35, the speed reduction unit 36 is fixedly mounted to the bottom of the outer tank 24 and it is operated under the control of a microcomputer 71 through a clutch motor 84 as shown in Fig. 1 to effect switching between high speed and low speed, as will be described later.

A pulley 39 is fixed to a shaft 35a of the motor 35, a pulley 40 is fixed to an input shaft of the speed reduction unit 36, and a belt 41 is applied over the pulleys 39 and 40. A pulley 42 is fixed to an output shaft 36a of the speed reduction unit 36, and a belt 43 is applied over the pulley 42 and drum drive pulley 34.

In a through-flow type circulation fan 44, a casing 44b is divided into right and left two portions at the boundary including the center of an impeller 44a, and a suction port 44c is provided on the side of one portion and a release port 44d is provided on the side of the other portion. The fan is fixed to an upper portion of the side plate 24b of the outer tank 24 and during drying, it is operated to supply hot air to the drum 27 and circulate exhausted wet air, as indicated by arrows in Fig. 3.

A fan shaft 45 is supported on bearings at the front and back side plates of the casing 44b and a pulley 46 is fixed to the fan shaft 45. A heating chamber 47 is arranged internally of the center portion of the side plate 24b of outer tank 24 and fixed to the side plate 24b so as to be airtightly, snugly fitted in the recess 29a in the side plate 29 of drum 27. The lower half of the heating chamber has an opening 47a through which hot air is injected into the drum 27. An annular air-tightness maintaining member 48 is interposed between the recess 29a of the side plate 29 of drum 27 and the heating chamber 47. A sheathing heater 49 for heating wet air to be circulated and supplied to the drum 27 during drying is accommodated in the heating chamber 47.

A drainage chamber 50 is connected to the drainage port 24e of the outer tank 24 and it has a drainage hole 50a in communication with a drainage valve 55, a hole in communication with a trap 53 and a connection to a duct 51. The duct 51 extends upright from the drainage chamber 50 and connects to the suction port 44c of the circulation fan 44, having a midway sprinkler port 52 connected to a water feed valve (C) 61 and being operable to sprinkle cooling water downwards. The drainage valve 55 is in communication with the drainage hole 50a and a drainage hose pipe 56 is connected to a release tube of the drainage valve 55.

A fan motor 57 for driving the circulation

fan 44 is fixed to the bottom of the outer tank 24, a pulley 58 is fixed to the shaft of the fan motor 57 and a belt 59 is applied over the pulleys 58 and 46. Water feed valves (S) 60 and (C) 61 are integral with each other, having a common inflow port for water supply and individual independent release tubes.

The water feed valve (S) 60 is opened during washing and rinsing to feed water into the outer tank 24 and the water feed valve (C) 61 is opened during drying to sprinkle cooling water into the duct 51. A flow rate limiter 62 is connected to the release port of the water feed valve (C) 61 and is operable to automatically change its flow path area in accordance with the magnitude of water pressure of water supply in order to feed into the duct 51 cooling water which is always at a constant flow rate. A water absorber 63 is formed of water absorbent, longitudinally elongated plate materials which are accommodated in the duct 51 so as to be juxtaposed, leaving behind gaps therebetween. Reference numeral 64 designates a water feed hose pipe, 65 a water teeming hose pipe for connecting the release port of the water feed valve (S) 60 and the water teeming port 24f of the outer tank 24, and 66 a tube of small diameter.

Shock absorbers 67 are each comprised of a rod 67a and a buffer 67b incorporating a compression coil spring and they are hung on four corners of the outer frame 21 to buffer support the outer tank 24.

Referring now to Figs. 7 to 9, the construction of a rotational position detector for detecting the rotational position of the drum will be described.

Fig. 7 is a partly exploded front views showing the construction of the rotational position detector mounted near the rotary shaft 33 of the drum 27, and Fig. 8 is a sectional view of Fig. 7.

Illustrated in these Figures are the rotary shaft 33 of the drum 27, the pulley 34, the belt 43 for transmitting torque of the motor 35 to the rotary shaft 33 of the drum 27, an interrupter holder 3 mounted to the side plate 24c, reflection type photo-interrupters 4, 5 and 6 carried on the interrupter holder 3 (each interrupter being an optical coupling device which is comprised of a light emitting element and a light receiving element and in which the light receiving element receives light, emitted from the light emitting element and returning in the form of reflection light, to produce an output), and a reflection plate 2.

Fig. 9 is a front view of the reflection plate 2 shown in Fig. 8. Referring to Fig. 9, a pattern 7 is located at the outermost circle, a pattern 9 is located at the inner circle and a pattern 8 is located at the intermediate circle. Denoted by 10 is a hole through which the rotaty shaft 33 is inserted.

The reflection plate 2 is fixed to the pulley 34 and rotated along with the drum 27. The reflection plate 2 has the patterns 7, 8 and 9 as shown in Fig. 9

which are set up by using black portions of low optical reflection factor and white portions of high optical reflection factor. The interrupter holder 3 opposes the patterns on the reflection plate 2 and immovably secured to the side plate 24c of the outer tank 24. The reflection type photo-interrupters 4, 5 and 6 on the interrupter holder 3 have a focal distance of 4 mm. The reflection type photo-interrupter 6 opposes the pattern 7; and similarly, the interrupter 5 opposes the pattern 8 and the interrupter 4 opposes the pattern 9. Signals of "0" or "1" corresponding to black portion or white portion of the pattern 9 can be obtained from each photo-interrupter. Since in this example, the patterns 8 and 9 are dephased from each other, the reflection type photo-interrupters 5 and 4 generate a two-phase signal of 90-degree phase difference as the drum 27 rotates.

The direction of rotation of the drum 27 is determined by using the two-phase signal and for example, when the drum 27 rotates to the right, that is, clockwise, output signals of the photo-interrupters are counted up by means of a counter (the microcomputer 71 in Fig. 1) and when the rotation is to the left, the output signals are counted down, thereby making it possible to know a rotational position of the drum 27.

The pattern 7 is positioned to oppose the reflection type interrupter 6 when the drum lid 31 is aligned with the opening 24d of the outer tank 24, so that

a reference position signal may be delivered.

The controller cooperating with the above construction will now be described with reference to Fig. 1.

The microcomputer 71 is the heart of control and receives the two-phase signal and reference position signal from the rotational position detector, as designated by reference numeral 1, and input signals from a cloth amount detection unit 87, a deflection sensor 74 not shown in Figs. 2 to 6 which is adapted to detect vibrations of outer tank 24 caused during dehydration, a water level sensor 75 not illustrated in Figs. 2 to 6 which is adapted to detect the water level of washing water supplied from a bibcock to the outer tank 24 through the water feed hose pipe 64 and water teeming hose pipe 65 and filled in the outer tank, operation/input means 73 and a zero-cross circuit 76 adapted to detect timings at which voltage of an AC power supply 88 assumes zero.

The microcomputer 71 is associated with output units including a display unit 72 for displaying decision results of the cloth amount in the form of, for example, documents, sound or voice and an instruction for expediting the next operation, the motor 35, the clutch motor 84 for switching the speed reduction unit 36, the fan motor 57, a drainage motor 85 for open/close of the drainage valve 55, the sheathing heater 49 and a water feed solenoid 86 for open/close of the

water feed valve 60. Excepting the display unit, the output units are connected to the microcomputer 71 through AC switches 77, 78, 79, 80, 81, 82 and 83 which are constructed of, for example, SSR's (solid-state relays).

Referring now to Figs. 10 and 11 and PAD's (problem analysis diagrams) of Figs. 12 to 15, the manners of selecting operations and detecting the cloth amount in the full-automated washing and drying machine according to the invention will be described.

Fig. 10 shows an example of operation where decision of the cloth amount is carried out through two steps and Fig. 11 shows another example where the cloth amount decision is effected through three steps.

As is clear from Figs. 10 and 11, in the full-automated washing and drying machine of the invention, when the power supply is turned on and cloths standing for the washing are charged into the drum 27, the cloth amount detection is first carried out in advance of water teeming.

The cloth amount detection unit 87 may be based on a variety of methods such as a method to be described later for determining inertia of cloths, a method described in, for example, Japanese Patent Application Laid-open Hei 2-241493, page 11 wherein the weight of cloths is detected by measuring strain in the shock absorbers 67 (or called suspensions) adapted to buffer support the outer tank 24 by means of a strain

gauge, a method ad described in Japanese Patent Application Sho 63-283174 which utilizes electromotive force reflecting weight applied to a piezoelectric sensor carried on the shock absorber 67, and a method as described in Japanese Patent Application Laid-open Sho 57-115286 which detects the height of washing cloths by means of an ultrasonic sensor.

When the cloth amount detection is completed, it is decided by decision means comprised of the micro-computer 71 on the basis of information indicative of cloth amount detection results whether drying is permitted for execution or not.

When drying is decided to be permissible in the case of Fig. 10, a document stating, for example, "Does the operation extend to drying?" is first displayed on the display unit 72. If an operation key (not shown) of operation/input means 73 corresponding to, for example, "Y (or 1)" is depressed, a drying course covering washing, rinsing, dehydration and drying is set by means of automatic setting means comprised of the microcomputer 71 and operation is started. If "N (or 2)" is depressed, a washing course beginning with washing and subsequent rinsing and ending in dehydration is similarly set and operation is started.

On the other hand, when drying is decided to be impermissible, documents, for example, "1: Is the amount of cloths decreased?", "2: Does the operation

end in dehydration?" and "3: Are the cloths as they are dried?" are displayed on the display unit 72 to expedite the next operation. If the user depresses an operation key (not shown) corresponding to "document 1", "Decrease the amount of cloths. Are you ready?" is displayed on the display unit 72. Then, when the user decreases the amount of cloths and depresses, for example, the operation key (not shown) of operation/input means 73 corresponding to "Y (or 1)", the aforementioned drying course is similarly set and operation is started. If an operationkey (not shown) corresponding to "document 2" is depressed, a document, for example. "The operation begins with washing and ends in dehydration" indicative of the results of setting is displayed on the display unit 72, the washing course is set by means of the automatic setting means and operation is started. If an operation key (not shown) corresponding to "document 3" is depressed, a document, for example, "The cloths as they are dried" indicative of the results of setting is displayed, the drying course is set by means of a first automatic setting means comprised of the microcomputer 71 even when the cloth amount is large, and operation is started.

In Fig. 11, decision means performs three-step discrimination inclusive of fuzziness which is represented by a first state of "The operation is permitted to extend to drying", a second state of "The cloth amount is slightly excessive for drying" and a

third state of "The cloth amount is too large to effect drying". Accordingly, when the first state is determined, display and setting are carried out in a similar manner to the case where drying is decided to be permissible in Fig. 10. When the second state is determined, display and setting are executed in a similar manner to the case where drying is decided to be impermissible in Fig. 10. When the third state is determined, a document, for example, "Is the cloth amount decreased?" is displayed on the display unit 72. Then if, for example, the operation key (not shown) of operation/input means 73 corresponding to "Y (or 1)" is depressed, "Decrease the cloth amount" is displayed to expedite the next operation. The operation then returns to the cloth amount detection, thereby ensuring that it is possible for the operation to extend to drying. If "N (or 2)" is depressed, the washing course beginning with washing and subsequent rinsing and ending in dehydration is similarly set by means of a second automatic setting means comprised of the microcomputer 71, a document, for example, "The operation begins with washing and ends in dehydration" indicative of the results of setting is displayed on the display unit 72, and operation is started.

The operational principle of the cloth amount detection unit 87 according to the invention which is based on the method for determining inertia of cloths and which does not require any separate sensor will

now be described. The principle will first be outlined and then detailed. Fig. 12 shows a schematic PAD of the entirety of the present detection system and the following description will be given in accordance with Fig. 12.

In the present cloth amount detection system, a quantity corresponding to minimum electric power necessary for starting the container (drum 27) charged with cloths by means of the motor 35 is first detected as an angle of electric conduction applied from the AC power supply to the motor 35 by using the rotational position detector 1. This detection is repeated a few times to improve accuracies. Subsequently, an amount of an overrunning rotation beginning with turn-off of the power supply for the motor 35 and ending in stoppage of the drum 27 following its rotation due to inertia is detected using the rotational position detector 1. Similarly, this detection also repeats itself a few times to obtain a mean value used as a detection value.

Values of the two types of detections are used by the microcomputer 71 to determine the amount of cloths in the drum 27 through, for example, fuzzy deduction process.

The manner of detecting the quantity corresponding to power necessary for starting as the angle of electric conduction applied from the AC power supply will be described in greater detail with reference

to Fig. 14.

An AC voltage waveform supplied from AC power supply 88 to motor 35 is illustrated in Figs. 17A, 17B and 17C. In the voltage waveform, the timing at which voltage of the AC power supply assumes zero is detected by the zero-cross circuit 76 and a detection signal is applied to the microcomputer 71. Subsequently, lagging time DT following the zero-cross point is set. Then, a trigger pulse of about 2 to 3 ms is applied from microcomputer 71 to solid-state relay 77 to turn it on. As a result, power corresponding to a hatched area in the half cycle is supplied to the motor 35. Thus, a conduction angle applied to the motor 35 is defined by a phase angle which corresponds to an interval of time between the termination of lagging time DT and the succeeding zero-cross point. (Practically, it is preferable that the operation be started at a conduction angle of about 30 degrees.)

On the other hand, during the above procedure, the rotational position detector 1 continues supplying the aforementioned two-phase signal to the microcomputer 71.

The above operation repeats itself by about 2 to 6 cycles while confirming by using the rotational position detector that during this phase of operation, the motor 35 is not started yet and consequently the drum 27 does not start rotating.

Thereafter, the lagging time DT is decreased

by δT which is about 0.25 ms and under this condition, the operation similarly repeats itself by 2 to 6 cycles. In other words, the conduction angle is increased slightly to increase power supplied to the motor 35. During this procedure, the rotational position detector 1 fetches data of two-phase signal as shown in a PAD of Fig. 13. As the drum 27 starts rotating, the data changes to reach a predetermined count value, for example, 4 which defines starting of the drum. A value corresponding to a conduction angle at that time is defined as a value representative of power required for starting the motor 35. This value is indicated by (FKDAT1).

The manner of detecting the overrunning rotation amount will now be detailed with reference to Fig. 15.

Firstly, after cloths are charged into the drum 27, the motor 35 is driven, for example, clockwise to rotate the drum clockwise by one or more revolution. As the rotary shaft 33 rotates along with the drum 27, the timing comes at which the pattern 7 on the reflection plate 2 opposes the photo-interrupter 6 to cause it to deliver the reference position signal. At that timing, the reference position signal, as designated by Z, changes its value from 1 (high) to 0 (low) because the pattern 7 is a black portion of low optical reflection factor.

At the timing that the value of the reference

position signal changes from 1 to 0, the motor 35 is deactivated (or electromagnetic braking is applied). Concurrently therewith, the microcomputer 71 resets the count value (encnt) obtained from the rotational position detector 1 to zero and restarts the counting.

Since the motor 35 is deactivated from the power supply, the drum 27 then continues rotating by its inertial force which depends on cloths contained in the drum 27. Throughout the continuation of this rotation, the rotational position detector 1 transmits the two-phase signal to the microcomputer 71 which in turn continues counting the count value (encnt). When the drum 27 subsequently stops, the count value (encnt) is detected as an overrunning rotation amount (FKDAT2) of the drum 27 following the deactivation of the motor 35 and stored in the micrcomputer 71.

The previously obtained value (FKDAT1) corresponding to the conduction angle for starting and the thus obtained value of overrunning (FKDAT2) can be expressed by the following equations:

$$FKDAT1 = C1 \cdot M + C2 \cdot F$$

$$FDKAT2 = C3 \cdot M - C4 \cdot F$$

where M: moment of inertia of cloths and drum 27

F: frictional loss in mechanism components

C1 to C4: constants determined by a washing machine used (C1, C3, C2 · F and C4 · F are determined experimentally.)

Accordingly, from the two values, a value X effective to minimize the influence of frictional loss F can be obtained as a decision criterion for cloth amount detection, as follows:

$$X = FKDAT1 + FKDAT2$$
$$= (C1 + C3)M + (C2 - C4)F$$

If FKDAT1 or FKDAT2 is multiplied by constant C so that $C2 - C4 = 0$ may stand, then there results

$$X = FKDAT1 + C \cdot FKDAT2$$
$$= CC \cdot M$$

In this manner, the value X is affected by only the moment of inertia of cloths and the drum 27. (CC is determined experimentally.)

In the full-automated washing and drying machine, the amount of cloths must be detected while the cloths remain dried (before water is teemed). Obviously, the moment of inertia due to the cloth amount is less affected by dry cloths than wet cloths and therefore, under the dry condition, high accuracies are required for detecting a cloth amount from a change in moment of inertia. Further, in detecting weight of cloths, a strain gauge is used to measure a maximum value of cloth amount of 5 kg with a requisite value of resolution of 1 kg or less and also a total weight of 30 to 40 kg of drum 27, outer

tank 24 and motor 35 which are suspended from the shock absorbers 67. Therefore, highly accurate resolution is also required within the range of measurement of the strain gauge. This holds true for emasurement based on pressure. In detecting the height of cloths of the washing by means of an ultrasonic sensor, the top surface of the washing becomes disadvantageously unsettled depending on the manner of laying the washing. Under the circumstances, it is recommended that a plurality of values which are substantially proportional to the cloth amount, that is, such values as detected by the above means be selected and a decision criterion for cloth amount be determined through fuzzy deduction by using the selected values in the conditional part.

Likewise, the detection of values corresponding to the conduction angle for starting and the overrunning amount is liable to be incomplete depending on conditions of temperature, humidity and the manner of laying cloths. But since the terms representing frictional loss can be cancelled out, highly accurate measurement can be expected. Thus, fuzzy deduction based on the two types of values of conduction angle and overrunning amount to determine a decision criterion for cloth amount may be employed as will be exemplified below.

The conditional part of deduction uses the value corresponding to a conduction angle for starting (FKDAT1) and the value of an overrunning amount (FKDAT2) to deduce a cloth amount in the conclusion part.

For example, membership functions as shown in Figs. 16A and 16B are defined for values corresponding to conduction angles for starting (FKDAT1) and values of overrunning amount (FKDAT2), and function values are determined by looking up the membership functions. When the membership functions are defined as illustrated by sorting the values corresponding to conduction angles for starting (FKDAT1) into three fuzzy levels of (large, medium, small) and the values of overrunning amount (FKDAT2) into four fuzzy levels of (large, slightly large, medium, small), (3 x 4) = 12 deduction rules in total are available.

In deduction operation, grades in the conditional part are first determined, deduction results in the conclusion part are then obtained in connection with the individual rules and the decision criterion for cloth amount is determined through centroid method.

Operation of deduction is carried out in sequence as below.

(1) Grades in the conditional part are determined from measured values FKDAT1 and FKDAT2.

(2) Deduction results are obtained to indicate which fuzzy sets in the conclusion part belong to by the individual fuzzy inference rules. For example, a fuzzy set UL designated in the conclusion part is multiplied by one grade w1 in the conditional part to obtain U1 x w1.

(3) All fuzzy sets in the conditional part are

subjected to similar calculation and deduction results obtained for the individual rules are synthesized.

(4) The center of gravity of a sum set thus synthesized is determined to provide an output representative of a decision criterion for cloth amount.

In an alternative, membership functions in the conditional part may be defined by straight lines, the value in the conclusion part may be defined by a linear form which resembles the previously described value X, and output values obtained in connection with individual rules may be subjected to weighted average to provide a decision criterion for cloth amount.

For the cloth amount, a criterion reading, for example, "If the value corresponding to a conduction angle for starting (FKDAT1) is small, then the cloth amount is small even when the value of overrunning amount (FKDAT2) is large." is stipulated in connection with a rule and the cloth amount is decided in accordance with the criterion.

Fuzzy stipulations are then applied to the decision criterion for cloth amount so that any one of three indications may be obtained finally which are (1) not greater than the capacity for drying (the operation can extend to drying), (2) the cloth amount is slightly large (the amount of cloths should be decreased if possible) and (3) the cloth amount is large (the amount of cloths should be decreased).

The indication is displayed on the display

unit 72 as described previously in order for the user to be informed of the indication. Accordingly, when the indication is, for example, "the cloth amount is slightly large", the user is permitted to operate the machine by deciding as to whether the operation should extend to drying with the cloth amount decreased, whether the operation should end in dehydration through washing and rinsing with the cloth amount remaining unchanged or whether the operation should extend to driving with the cloth amount remaining unchanged.

In particular, the machine construction can be rationalized to improve ease of operation in that when indication "(2) the cloth amount is slightly large (the amount of cloths should be decreased if possible)" is displayed, the user can decide as to whether the operation should end in dehydration following washing and rinsing or whether the operation should extend to drying, and when "(3) the cloth amount is large (the amount of cloths should be decreased)" is displayed, the operation can automatically end in dehydration through washing and rinsing.

In the foregoing embodiment, the overrunning amount due to inertia of the drum 27 is detected using the rotational position detector 1 adapted to detect rotational of the rotary shaft 33 but it may also be determined by turning off the motor 35 realized with a capacitor-induction motor as usual and then counting a number of pulses representative of voltage across

capacitor.

Control means for varying power during starting has been described as being a conduction angle control system but alternatively it may be constructed of an inverter system.

Further, the rotational position detector 1 for generating the 90-degree dephased, two-phase signal has been described as being an incremental type encoder but it may alternatively be a 6-bit absolute type encoder which meets a value of resolution of 36 possessed by the rotational position detector 1.

In accordance with the invention, the drum can be stopped at a home position in a manner as will be described below.

The method for home-position stoppage of the drum will be detailed with reference to a PAD of Fig. 18.

Firstly, the motor 35 is driven unconditionally in, for example, clockwise direction as viewed from Fig. 3 to rotate the drum 27 by revolution of one or more. During the rotation, the microcomputer 71 fetches, as data, a two-phase signal from the rotational position detector 1. Driving of the motor 35 continues until "0" (low level) of reference position signal (Z) is produced. When Z = 0 is reached, the motor 35 is deactivated (or electromagnetic braking is applied). Concurrently therewith, a ring count value (RGCNT) produced from the rotational position detector 1 is set to zero.

After the deactivation of the motor 35, the drum 27 continues rotating by its inertial force. During this interval of time, the rotational position detector 1 continues counting the two-phase signal. Through processing by the microcomputer 71, the two-phase signal is converted into the ring count value (RGCNT) having levels of 0 to 35 of which 0 (zero) occurs at the reference position.

A level of the ring count value (RGCNT) obtained when the drum 27 stops is stored as data of overrunning amount (FKCNT). If a value of FKCNT is zero indicating that the drum lid 31 is aligned with the opening 24d, the procedure ends. But if the value of FKCNT is not zero, a level (STPCNT) of ring count value (RGCNT) which is representative of a timing for a halt signal to be applied to the motor 35 is determined from STPCNT = 36 - FKCNT. For example, if the motor 35 deactivated at the reference position where the level of ring count value is zero stops at 2 of ring count value (RGCNT), that is, at data of FKCNT = 2, then the timing for the application of the halt signal (the deactivation of the motor 35) is changed to an instant at which data of STPCNT = 36 - 2 = 34 is obtained, in expectation of the succeeding stoppage at the referenc. position of zero level of the ring count value.

Accordingly, the motor 35 restarted for rotation may be deactivated when the ring count value (RGCNT) coincides with the halt count (STPCNT).

The above method can esnure an error of about ±1 count and it is in general satisfactory. Practically, however, the load amount changes greatly in the case of the drum type washing and drying machine and the machine is operated under various conditions. Thus, the accuracy of stop position of the drum 27 may be improved and adapted for various conditions as will be described below with reference to PAD's of Figs. 19A and 19B and waveforms of Figs. 17A, 17B and 17C.

Firstly, it is assumed that after the stoppage of the drum 27 effected in accordance with the aforementioned method, data of the ring count value (RGCNT) is obtained which normally falls within the range of ±1 count relative to the reference position of zero level of the ring count value. If the data is coincident with the zero reference position, no problem occurs; but if non-coincident, a direction in which the drum 27 is to be driven is decided on the basis of the data of the ring count value (RGCNT). The conduction angle for power supplied from the AC power supply to the motor 35 can be limited to 90 degrees by applying the trigger pulse as shown in Fig. 17B. The manner of applying this trigger pulse will be described with reference to Fig. 19B showing a PAD for a subroutine of trigger pulse generation.

Firstly, the timing for voltage of the AC power supply to assume zero is detected and lagging time DT from that timing is set to 5 ms for 50 Hz. (For

simplicity of explanation, the initial conduction angle is set to 90 degrees but practically, it may preferably be about 30 degrees.) At that phase, the trigger pulse is generated during an interval of time of about 2 to 3 ms. The above procedure is repeated through about 2 to 6 cycles. Subsequently, the lagging time DT is reduced by δT of about 0.25 ms to assume 4.75 ms and the procedure is repeated through 2 to 6 cycles. During these procedures, the rotational position detector 1 fetches data. The above operation is repeated and when the ring count value (RGCNT) assumes zero, power conduction to the motor 35 is stopped (or electromagnetic braking is applied). Since the motor is started at the reduced conduction angle, vibration can be reduced to advantage and in addition, the overrunning amount occurring after the application of the halt signal can be decreased.

In this embodiment, the overrunning amount due to inertia of the drum 27 is detected using the rotational position detector 1 but it may also be determined by turning off the motor 35 realized with a capacitor-induction motor as usual and then counting a number of pulses representative of voltage across capacitor.

Further, the rotational position detector 1 for generating the 90-degree dephased, two-phase signal has been described as being an incremental type encoder but it may alternatively be a 6-bit absolute type encoder which meets a value of resolution of 36 possessed by

1 the rotational position detector 1.

Furthermore, in the full-automated washing machine and the full-automated washing and drying machine, the same rotational position detector 1 as that used for detection of the home-position stoppage of the drum 27 may advantageously be used for detection of the forward/reverse rotation of the drum 27 when the rotation angle is not fixed but is changed in accordance with random number in the course of forward/reverse rotation of the drum, thereby attaining effects that non-uniformity in washing and drying can be suppressed to realize a rational construction which is advantageous from the standpoint of cost.

On the assumption that the resolution of the rotational position detector 1 is 36, because of the revolution number of the drum 27 during washing being set to about 100 rpm, the time per one division unit amounts to 17 ms/count and this value approximating 20 ms of the period of the AC power supply is suitable for controlling the capacitor-induction motor; and besides because of the diameter of the drum 27 being about 420 mm, about 40 mm/count measures at the circumference of the drum lid 31 and this value is proper for accuracy of stoppage of the drum 27.

Referring now to Figs. 20A to 20D, the manner of operating the drum 27 will be described.

Firstly, when washing, the washing and a cleanser are charged into the drum 27 and washing water

is supplied to the outer tank 24 to a water level which is at least below the horizontal axis passing through the center axis of the drum 27 and which typically corresponds to about 1/3 of the capacity of the drum 27. Thereafter, the motor 35 is driven to start, for example, counterclockwise rotation of the drum 27 (rotary shaft 33) as illustrated in Figs. 20A and 20B.

At the same time, the reflection plate 2 is also rotated, so that a two-phase signal is produced from the photo-interrupters 4 and 5 opposing the patterns 9 and 8 and a rotation angle of the drum 27 is detected. On the other hand, the washing is scooped up while being stirred by the lifters 28 formed on the inner periphery of the drum 27.

Thereafter, as shown in Fig. 20B, the activation of motor 35 continues to forcibly rotate the drum 27 until the drum is rotated by at least 1/2 or less of revolution, typically, 1/4 revolution. The time for this rotation is defined as a forcible rotation interval of drum running.

At the termination of the forcible rotation interval, the motor 35 is deactivated and the drum 27 continues rotating by its inertia as shown in Fig. 20C. The time for this rotation is defined as an inertial rotation interval of drum running.

At that time, the washing is washed by utilizing the fall relative to the water surface. At the termination of the inertial rotation interval, the drum

27 starts rotating reversely or clockwise in this explanation, beginning with the initial state as shown in Fig. 20D. The operation during the clockwise rotation resembles the previously-described operation with the exception that the inertial rotation interval for clockwise rotation as shown in Fig. 20C is set to 0.3 to 0.6 seconds which differs from that for counterclockwise rotation amounting up to 1 to 2 seconds, in order to make the forward/reverse rotation asymmetrical. Accordingly, the inertial rotation angle of the drum 27 is smaller in the clockwise rotation than in the counterclockwise rotation.

Subsequently, the above forward/reverse rotation is repeated to continue the washing operation. Accordingly, in this example, the washing sequentially shifts in the counterclockwise direction by a slight amount corresponding to the asymmetry of the forward/reverse rotation, thus reiteratively undergoing mechanical energies for swinging, stirring and dropping the washing. Further, when washing, the rotation angle of the drum 27 which proceeds during one cycle of the forcible and inertial rotation intervals is so set as not to exceed one revolution, in order that vibrations which would be due to reaction force caused by running of the outer tank 24 can be avoided. This can be done by the reversing of rotation which takes place before the unbalanced amount of the washing excites a vibratory system comprised of the shock absorbers 67. Practically, the rotation

angle is determined experimentally depending on the magnitude of vibration and washing power, having the aforementioned values as optimum ones. Consequently, displacement of the drum 27 due to vibration can be minimized, making it possible to minimize the size of the outer frame 21 to advantage.

In the precedence, the inertial rotation interval has been described as being asymmetrical but alternatively the forcible rotation interval may be asymmetrical to proceed, for example, 1/4 revolution in the counterclockwise direction and 1/5 revolution in the clockwise direction.

In the succeeding rinsing and drying operations, the drum 27 is operated in a manner similar to the above.

With the construction described as above, the present invention is expected to attain the following effects.

(1) At the time that cloths are charged, the user is informed, in advance of teeming water, of whether the amount of cloths permits the operation to extend to drying or not. If a negative indication is displayed, then the user is permitted to determine that the cloth amount should be decreased, with the result that such incovenience as generation of wrinkles at the termination of drying can be prevented and ease of operation can be improved.

(2) At the time that the washing (cloths) is charged, the cloth amount is decided, in advance of

teeming water, as to whether to be permissible for drying or not and a result of decision is displayed and the user is informed of the result. Therefore, in advance of teeming water, the user can select the next operation in accordance with information about the cloth amount by deciding as to whether the operation should extend to drying, whether the cloth amount should be decreased or whether the operation should end in dehydration following washing without extending to drying. Accordingly, such inconvenience that the operation expected to extend to drying is forced to end in dehydration can be prevented and ease of operation can be improved.

(3) When the indication of the cloth amount is stipulated in three steps of (1) not greater than the capacity for drying (the operation can extend to drying), (2) the cloth amount is slightly large (the amount of cloths should be decreased if possible) and (3) the cloth amount is large (the amount of cloths should be decreased), the operation meeting various conditions of cloth quality can be carried out. For example, even when "(2) the cloth amount is slightly large" is displayed, for the washing allowed to be slightly wrinkled, the operation can be extended to drying with the cloth amount remaining unchanged.

(4) The user is permitted to determine that the operation is allowed to extend to drying when indication "(2) the cloth amount is slightly large (the amount of

cloths should be decreased if possible)" is displayed, but the operation automatically ends in dehydration through washing when indication "3 the cloth amount is large (the amount of cloths should be decreased)" is displayed, thus making it possible to provide a rational, full-automated washing and drying machine.

(5) When the decision criterion for cloth amount is determined on the basis of values corresponding to the overrunning amount and the conduction angle for starting in accordance with teachings of the invention, changes in ambient temperature and changes in rotational, frictional loss in the drum due to changes in tension in the V belt connecting the motor and the rotary shaft of drum can be neglected and steadiness of cloth amount detection can be ensured.

(6) When the decision criterion for cloth amount is determined through fuzzy deduction using, as values related to cloth amounts obtained from a plurality of means, values corresponding to the overrunning amount and the conduction angle for starting, the thus determined decision criterion for cloth amount can take advantage of empirical knowledge of various conditions of temperature, humidity and the manner of laying cloths.

The invention can attain further effects as below.

(7) Since the overrunning amount is once detected following deactivation of the drum 27, the drum 27 can

assume the home position regardless of inertial force due to load amounts and frictional loss in shafts.

(8) When the overrunning amount after deactivation of the drum 27 is determined by counting a number of pulses across capacitor of a capacitor-induction motor, the conventional cloth amount detector circuit can be used as it is to advantage from the stand-point of cost.

(9) When the rotational position detector 1 is realized with an incremental type encoder, the number of signal lines can be minimized to provide high resolution.

(10) When an absolute type encoder is used as the rotational position detector 1, the number of signal lines are increased but the encoder does not cause shifting of data even when the power supply is turned off in the course of stop operation of the drum 27, thus simplifying the processing by the microcomputer.

(11) When the encoder is constructed of the reflection plate 2 carried on the pulley 34 and the reflection type interrupters 4, 5 and 6 fixed to the outer tank 24, the wiring processing can be simplified and appropriate resolution can be obtained.

(12) By controlling the rotation angle during washing, drying and dehydration by means of the same rotational position detector as that used for stopping the drum 27 at the home position, rotation angle control not depending on the load amoutn can be ensured to advantage from the standpoint of cost.

(13) Random number values are applied to values of the forward/reverse rotation angle of the drum 27 to contribute to reduction of non-uniformity in washing and drying.

(14) With a value of resolution of the rotational position detector 1 set to about 36, time per one division unit substantially equals the period of the AC power supply and this value is proper for accuracy of stoppage of the drum 27.

(15) By deciding the drive direction of the motor 35 after the drum 27 is stopped at the home position in accordance with the above method, driving the motor at the conduction angle which varies from a small value to a large value in a so-called soft start fashion and stopping power conduction when the reference position is reached, accuracy of stop position of the drum 27 can be improved.

Further, the invention can attain the following effects.

(16) For removal of dirts, it is indispensable to provide the action for weakening force interacting fibers of cleanser and particles of dirts and the mechanical energies for separating dirts from fibers. In accordance with the invention, the rotation angle can be detected even when the amount of the washing is excessive and the mechanical energies can be applied uniformly to the washing, thus making a contribution to promotion of washing power.

(17) Non-uniformity in washing can be minimized.

(18) When drying, similar operations can be carried out to decrease non-uniformity in drying.

(19) Further, vibrations occurring especially during washing can be suppressed, making a contribution to size reduction of the washing and drying machine.

CLAIMS:

1. A full-automated washing and drying machine comprising:

a controller having a container into which cloths are charged and operable to perform washing by teeming water to the cloths charged into said container, then rinsing, dehydration and drying;

cloth amount detection means for detecting an amount of the cloths charged into said container, in advance of teeming water;

decision means for deciding in advance of teeming water whether the detected cloth amount is permissible for drying and so falls within such a limit value that the cloths can reach dried finish when the operation completes drying through washing and dehydration;

display means for displaying in advance of teeming water a decision result by said decision means;

operation/input means to be operated by the user who decides as to whether the operation should extend to drying or whether the operation should end in drying through washing and rinsing, so as to select the next operation in advance of teeming water; and

automatic setting means for automatically setting washing, rinsing, dehydration and drying processes in accordance with the operation of said operation/input means.

2. A full-automated washing and drying machine according to Claim 1 wherein said decision means includes means capable of discriminating and determining,

a first state that the detected cloth amount falls within the drying permissible limit value and is permissible for drying,

a second state that the detected cloth amount is near the limit value and for the purpose of sufficient drying, the cloth amount should be decreased if possible, and

a third state that the detected cloth amount exceeds the limit value and for the purpose of drying, the cloth amount should be decreased.

3. A full-automated washing and drying machine according to Claim 2 wherein said automatic setting means includes any one or both of

first automatic setting means operated by the machine user to automatically set the machine operation such that the drying process following washing and dehydration is executed without the cloth amount decreased even when said decision means determines the second state that the detected cloth amount is near the drying permissible limit value and for the purpose of sufficient drying, the cloth amount should be decreased if possible, and

second automatic setting means operated by the user to automatically set the machine operation such that the drying process following washing and dehydration

is not executed when said decision means determines the third state that the detected cloth amount exceeds the drying permissible limit value and for the purpose of drying, the cloth amount should be decreased.

4. A full-automated washing machine or a full-automated washing and drying machine comprising:

a container into which cloths are charged;

a motor for driving rotation of said container charged with the cloths;

a rotational position detector for detecting the rotational position of said container;

power corresponding quantity detection means for detecting a quantity corresponding to a minimum power level necessary for said motor to start said container charged with the cloths by using said rotational position detector;

rotation overrunning amount detection means for detecting a rotation overrunning amount by which said container continues rotating following turn-off of the power supply for said motor until it stops; and

cloth amount detection means for detecting the amount of the cloths in said container on the basis of the detected rotation overrunning amount and power corresponding quantity.

5. A full-automated washing machine or a full-automated washing and drying machine according to Claim 4 wherein said power corresponding quantity detection means includes:

an AC switch connected to a feed circuit adapted to supply AC power to said motor; and

means for detecting as the power corresponding quantity a value of the conduction angle for said AC switch which is gradually increased and detected when said rotational position detector detects starting of said motor.

6. A full-automated washing machine or a full-automated washing and drying machine comprising:

a container into which cloths are charged;

a mechanism including a motor for driving rotation of said container charged with the cloths;

a plurality of means for detecting a plurality of values substantially proportional to an amount of the cloths in said container; and

fuzzy logic unit for deducting the amount of the cloths in said container based on the plurality of values in the conditional part and the cloth amount by fuzzy inference rules.

7. A full-automated washing machine or a full-automated washing and drying machine according to Claim 6 wherein said plurality of means includes:

first means for detecting a first value which is substantially proportional to moment of inertia of the cloths in said container and frictional loss in components of said mechanism; and

second means for detecting a second value which is substantially in direct proportion to the moment

of inertia of the cloths in said container but is substantially in inverse proportion to the frictional loss in the components of said mechanism.

8. A full-automated washing machine or a full-automated washing and drying machine according to Claim 7 wherein said first means includes power corresponding quantity detection means for detecting as a first value a quantity corresponding to a minimum power level necessary for said motor to start said container, and said second means includes rotation overrunning amount detection means for detecting as a second value a rotation overrunning amount by which said container continues rotating following turn-off of the power supply for said motor until it stops.

9. A full-automated washing machine or a full-automated washing and drying machine having a home position stop unit for drum, said unit comprising:

a drum;

a motor for driving rotation of at least said drum;

a rotational position detector operable to generate, after deactivation of at least said drum, an output signal corresponding to a rotation overrunning amount beyond a rotation reference position for deactivation of said drum; and

control means, responsive to the output signal of said rotational position detector, to control at least the rotation stop position of said drum.

10. A full-automated washing machine or a full-automated washing and drying machine having a home position stop unit for drum according to Claim 9 wherein said control means controls the halt signal supplied to said drive motor on the basis of the output signal of said rotational position detector such that the halt signal is modified relative to the reference position of said drum.

11. A full-automated washing machine or a full-automated washing and drying machine having a home position stop unit for drum according to Claim 9 or 10 wherein said rotational position detector detects the overrunning amount beyond the reference position for deactivation of said drum by detecting the rotation overrunning amount of said drive motor.

12. A full-automated washing machine or a full-automated washing and drying machine having a home position stop unit for drum according to Claim 9, 10 or 11 wherein said rotational position detector includes an incremental type encoder operable to generate a 90-degree dephased two-phase signal as said drum rotates.

13. A full-automated washing machine or a full-automated washing and drying machine having a home position stop unit for drum according to Claim 8, 9 or 10 wherein said rotational position detector includes an absolute type encoder operable to generate a varying signal of a plurality of bits as said drum rotates.

14. A full-automated washing machine or a full-

automated washing and drying machine having a home position stop unit for drum according to Claim 12 or 13 wherein said encoder includes a reflection plate carried on a pulley and reflection type photo-interrupters fixed to an outer tank.

15. A full-automated washing machine or a full-automated washing and drying machine having a home position stop unit for drum according to Claim 9, 10, 11, 12, 13 or 14 wherein said control means controls the halt signal supplied to said drive motor such that the rotation angle of said drum having values represented in terms of random number is controlled in forward and reverse directions.

16. A full-automated washing machine or a full-automated washing and drying machine according to Claim 9 wherein said drum serves as a washing tank, a dehydration tank or a drying container and is supported horizontally by bearings inside a buffer supported outer tank and said rotational position detector includes an incremental type encoder for detecting the rotational position of said drum, said encoder being operable to detect the rotation angle of said drum when carrying out washing, drying or dehydration at low speed and after deactivation, detect the rotation overrunning amount of said drum beyond the reference position.

17. A full-automated washing machine or a full-automated washing and drying machine according to Claim 9 or 16 wherein resolution of said encoder is

represented in terms of the rotation angle of said drum and is about 10 degrees (one of 36 divisions of revolution).

18. A full-automated washing machine or a full-automated washing and drying machine having a home position stop unit for drum according to Claim 9, 10, 11, 12, 13, 14 or 15 wherein said control means includes decision means for deciding the drive direction of said drive motor on the basis of the output signal of said rotational position detector, and conduction angle control means for controlling the conduction angle of drive current of said drive motor, whereby when the conduction angle of drive current of said drive motor is gradually increased from a small value until the position of said drum reaches the reference position, electric conduction to said drive motor is so controlled as to be stopped.

19. A drum type full-automated washing machine or a drum type full-automated washing and drying machine having a drum serving as a washing tank, a dehydration tank or a drying container and supported horizontally by bearings inside a buffer-supported outer tank, said machine being operable to perform the operation which can extend to drying through washing and dehydration and comprising:

a motor for driving said drum;

lifters radially projecting from the inner peripheral surface of said drum; and

a rotational position detector operable to

generate an output signal corresponding to a rotation angle of said drum,

said drum being rotated alternately in forward and reverse directions during the sum of an interval of time for forcible rotation while detecting the rotation angle and an interval of time for inertial rotation which ends at the inversion of rotation.

20. A drum type full-automated washing machine or a drum type full-automated washing and drying machine according to Claim 19 wherein said inertial rotation time interval has different values for forward and reverse rotations of said drum.

21. A drum type full-automated washing machine or a drum type full-automated washing and drying machine according to Claim 19 or 20 wherein said forcible rotation time interval is asymmetrical for forward and reverse rotations of said drum.

22. A drum type full-automated washing machine or a drum type full-automated washing and drying machine according to Claim 19, 20 or 21 wherein said forcible rotation time interval represented in terms of the rotation angle of said drum is 1/4 to 1/2 revolution and one cycle of the sum of said forcible and inertial rotation time intervals does not exceed one revolution.

23. A full-automated washing machine or a full-automated washing and drying machine substantially as any of those described herein with reference to the accompanying drawings.

24. A drum-type full-automated washing machine or full-automated washing and drying machine substantially as any of those described herein with reference to the accompanying drawings.

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